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THE WONDER WORLD

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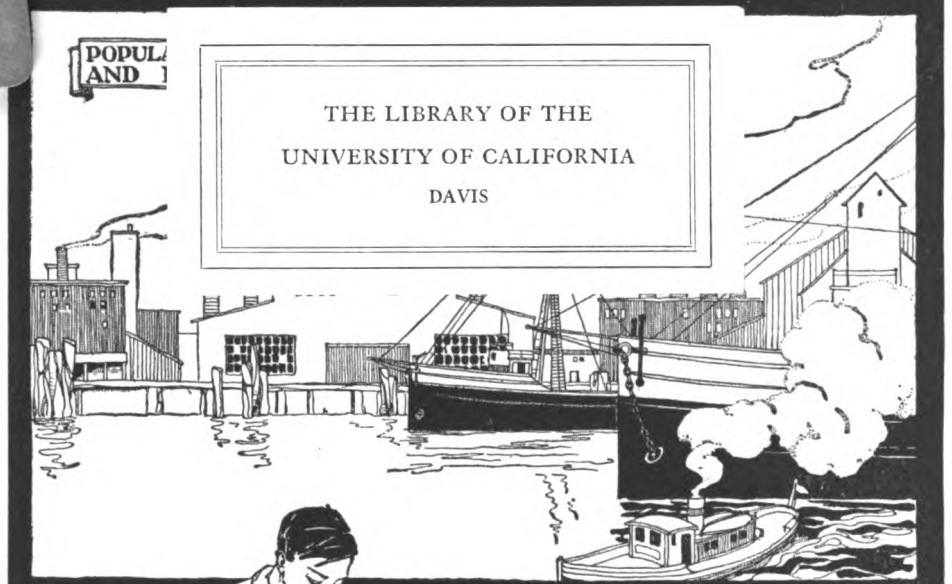

THE HUMAN INTEREST LIBRARY

OUR COUNTRY IN ROMANCE
OLD WORLD TRAVELOGUES
THE HUMAN INTEREST LIBRARY

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VISUALIZED KNOWLEDGE

VOLUME I.

CHICAGO
THE MIDLAND PRESS

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Today — every day — there is something we would like to know and to understand. "Learn one thing every day" might be the legend of THE HUMAN INTEREST LIBRARY. Its purpose is to acquaint the reader with the human interest facts of the world's knowledge through his devoting five minutes of spare time each day to interesting reading and to looking at instructive pictures.

ITS METHOD

In order that this knowledge may be acquired agreeably and without special effort, the facts have been woven into gripping human interest stories—stories that give in concise manner and without unnecessary detail, just what everyone wants to know about a famous person, place, picture or event. Each story is complete in itself and can be read in a few moments of spare time. If one story only is read every day, *every day* something worth while will be learned, and the reader will be quite unaware of any effort to acquire knowledge.

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More than a thousand illustrations, selected for their educational and inspirational value; nearly two hundred beautiful full-page engravings and numerous drawings by special artists have been used to fully illustrate all subjects treated and to visualize to a remarkable degree the story of man's achievements. Gathered from all available sources throughout the world, the paintings and photographs reproduced form a veritable picture gallery of the world's great men and great events.

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This book concerns many of the commonest things in life about which we, and especially those of us who are children, are continually wondering what the explanation may be. Very often these questions remain unanswered through life; because, perhaps, they are so simple. Here is a very marvelous book in which the ever recurring "Why" is answered. Whether it concerns the mysteries of the body or the far-off wonders of sun, moon and stars, the explanation is equally lucid.

BOOK OF OUR OWN LIFE.....89

In an age replete with discussion of matters relative to our physical well being, with public interest as never before focussed on physical culture, sex hygiene, eugenics and public sanitation, nothing is more timely than this very Book of Our Own Life. It traces human life from the cell to the full grown man and shows how the tiny microbes, the enemy of man, enter the blood stream, and the havoc they make. How the senses stand guard over the avenue of approach to the body and how the central nervous system from its seat in the brain, guides and directs all, is beautifully told in text and illustration.

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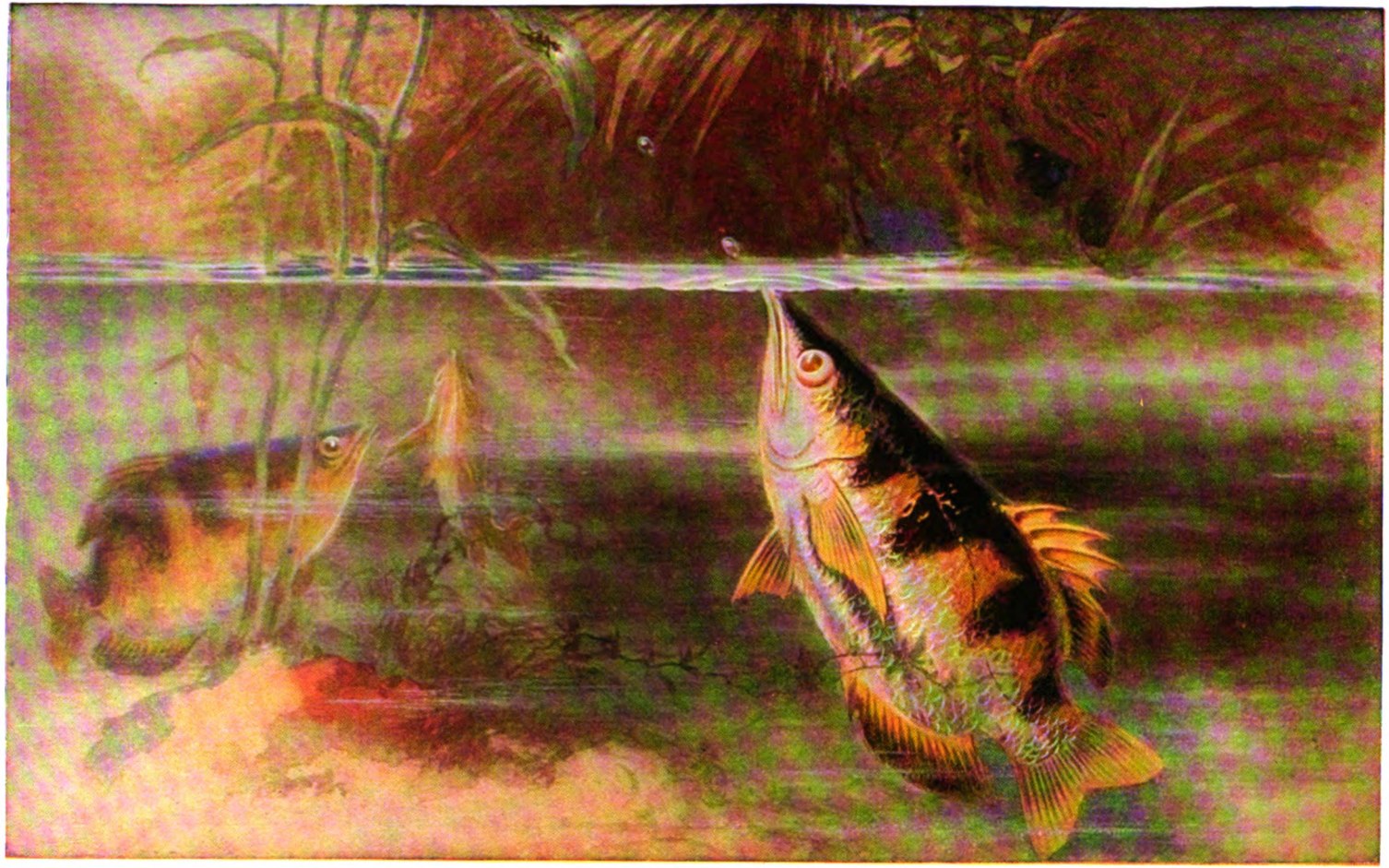


THE BATTLE OF THE PYGMIES AND THE STORKS

Homer and other ancient writers frequently refer to pygmy races which they represent as waging desperate warfare with the storks that came to raid their crops. Recently various expeditions have proved their existence in several parts of the globe.

THE EVERYDAY WONDER BOOK

WONDERS OF THE HUMAN BODY
WONDERS OF ANIMALS AND PLANTS
WONDERS OF LIGHT AND SOUND
WONDERS OF AIR, FIRE AND WATER
WONDERS OF EARTH, SUN AND STARS
THE CHILDREN'S "WHYS" AND "HOWS"
MISCELLANEOUS QUESTION-BOX

THE MYSTERIOUS SPECTRE OF THE BROCKEN

An enormously magnified image of the observer, cast upon a bank of mist, is sometimes seen in high mountain regions when the sun is low in the heavens and the observer is between the cloud bank and the sun; it is seen oftenest in the Harz Mountains, Germany.

THE REASON WHY

We are asking questions continually; all our lives we keep saying, "I Wonder Why." Where does the day begin? How do I remember? What makes the rainbow? To all of us come such questions, and as long as we live, such questions will come, however wise we grow. The questions will never stop as long as the world lasts, because out of the answer to one question another arises; and so, all over the world and down the ages of time, grown-ups and children have been saying, "I Wonder Why." All through these volumes we shall find the answers to our questions, but in this especial Book we shall find questions about many things which we particularly want to know. First of all, we learn how the world was peopled; then, how nations lived; how men know things that happened long ago, and how they gathered up the knowledge that is in the world. Later follows the answers to the puzzling workings of our own bodies, and the multitude of questions that come up from day to day about animals and plants; light and sound; air, fire and water; earth, sun and stars; and numerous other things we want to know about.

HOW THE WORLD WAS PEOPLED

IN the childhood of the world, there were not nearly so many people on the earth as there are today. We cannot tell exactly what happened then, because it is so very long ago; but we can make believe that all the people lived in one small part of the world all by themselves. They were like a big family living together in the same house. By-and-by the family grew bigger; more boys and girls began to come, and at last the house became too small for them to live in. So some of them had to go out and find another home. They wandered up and down over the earth, and when any of them found a comfortable place to live in, there they stopped and settled.

So, we are all one big family, and though now some nations seem very different from others, yet they are each some relation to the other, brother or sister, or cousin, or something. This is why we find so many of the same words used by different nations; the words father and mother, for instance, are alike in many different languages.

NATIONS LIVE AND DIE AND PASS AWAY AS YOU AND I

Some of these early nations have died, but others are still living today; for nations, just as we do, are born, grow up, and die, only it takes them a great deal longer time than it takes us. And perhaps some of the nations that are alive today will die and pass away some time in the future.

You may have wondered how we know about what happened long ago, before there were any books or newspapers, even before there was writing

of any sort. It is quite easy to find out what happened only a hundred years ago, because there are plenty of books that will tell us all about it. But what about things that happened thousands of years ago?

HOW WE KNOW THE STORY OF THE WORLD

The boys and girls who lived long ago were just as fond of stories as the children of today. They, too, would ask for stories; and when they grew up, they, too, would tell these stories to their children. So the stories came down to us, right from the earliest time, when there was no reading or writing, but simply story-telling. That is the first way in which we know what happened far back. Boys and girls have been among the most important people in handing on to us our story of the world. What a great loss it would have been if those boys and girls who lived once upon a time had forgotten the stories that were told them!

The next way of finding out what happened long ago is by reading the earliest books. What do you think these books were? Not books such as we have now, but bricks; just clay bricks, with writing and pictures marked on them while the clay was soft, and then baked hard in the heat of the sun. Thousands of these bricks have been dug out of the earth at Babylon and other places. When these cities were destroyed long ago, they became gradually covered with earth; the houses, the streets, the libraries, and everything in them were buried under the ground. And down under the ground these bricks have been kept dry and clean and fresh, and so today we are able to read the writing and the pictures, and find out what the people in those days were doing.

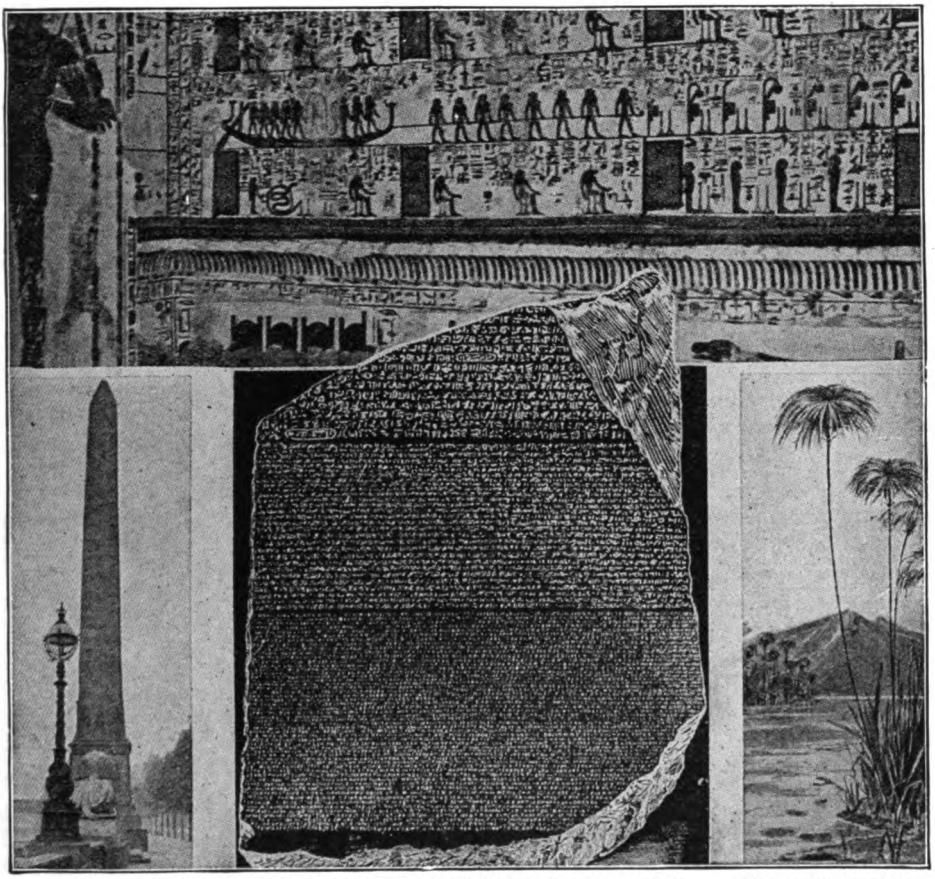
In ancient times, also, when a king did anything of which he was very proud, such as conquering his enemies and taking them captive, he had an account of it carved on a big stone or pillar, and set it up so that people could read all about what he had done. Thousands of these monuments have been found, and there probably are thousands still buried in Egypt, and parts of Asia. The writing on these stones looks very strange to us. Most of those found in Egypt have pictures upon them, instead of words and letters. When you are in New York, you should visit Central Park and look at the tall column called Cleopatra's Needle. This was brought from Egypt, and is covered with pictures; we call these pictures hieroglyphics, which means sacred carvings. When the first of these old pillars was found, no one could read the writing or understand the pictures. It was like a hard riddle.

At last, when all the learned men were very nearly giving up the riddle, a great piece of good fortune happened. Some French officers who were in Egypt about a hundred years ago, in 1799, happened to dig up a stone with writing on it, and, to their great delight, the writing was in three languages. One of these was the picture writing, and another was Greek. Now, it was easy enough to read the Greek, and when they had made out what that meant they guessed that the picture writing would mean just the same thing. And so it did. That gave people the key to the riddle, and the whole mystery was made clear. They found that an eagle stood for the letter *a*, a leg and foot for *b*, a serpent with horns for *f*, a hand for *t*, an owl for *m*, a chicken for *u*, and so on. A man with his hands lifted up meant *prayer*.

After reading this one stone, it was easy to read all the other writings on stones and pillars found in Egypt.

HOW THE WORLD'S STORY WAS FIRST TOLD

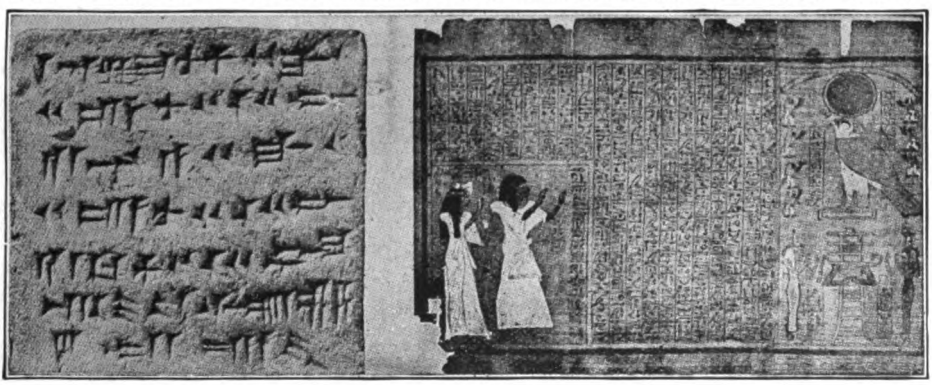
The Egyptians painted the walls of their temples and tombs with strange letters and pictures which tell the history of Egypt. This is from the wall of a tomb where the paint is still fresh, though it is thousands of years old.



Cleopatra's Needle, once in Egypt, and now standing in Central Park, New York, shows the strange writing on the Egyptian monuments.

The Rosetta Stone, which taught us to read the strange writing the Egyptians left behind. It said the same thing in three kinds of writing, and one kind was the Egyptian. Men knew one of the other kinds of writing, so that they were able to find out what the Egyptian writing meant.

There was no paper in old Egypt, and the people wrote on bricks and on the dried bark of the papyrus plant, here shown growing.



An early way of writing was to mark soft clay and bake it into a brick like this.

This is a piece of papyrus, showing how the Egyptians used it to write upon. Nearly all these things are in the British Museum.

This precious stone is known as the Rosetta Stone, because it was found at a place called Rosetta, and it can now be seen in the British Museum in London.

Another way in which we are finding out a great deal about early times is by the opening up of many tombs underground, especially in Egypt.

All kinds of things used to be buried with people in those days; so dry and air-tight were the tombs that everything in them has been wonderfully well preserved. Dolls have been found buried with the little girls who played with them long before Moses lived; a baby's rattle that amused a tiny brown Egyptian baby when Joseph was in Egypt; ladies' combs and mirrors, gold ornaments, and jewelry, worn perhaps when the Children of Israel were passing through the Red Sea. And so, little by little, we are finding out what life was like in the old days, and are piecing together the different bits of knowledge that we pick up, just as you put together the pieces of a puzzle to make the whole.

There is one more way in which we are being helped to do this, and that is by finding buried cities and towns just as they were hundreds of years ago. In parts of Asia, such as at Babylon, men are digging out whole towns that disappeared thousands of years ago.

It is well to remember that nothing happens by chance. There is a reason and a cause for everything. If we are wise enough we shall find out why we live and how we are related to one another. For we are really one big family; or we may say that the different nations are like the beads on a string—each bead is different and separate, but they are all joined together by the same string. Through all the story of the world we find this string joining up the beads; through it all we find some plan at work, and see God's hand in its guidance and control.

WONDERS OF THE HUMAN BODY

WHY WE GO TO SLEEP

WE GO to sleep so as to rest. The whole body rests when asleep, more or less—the brain, the heart, the lungs, the muscles, stomach and all. Children want a lot of sleep because children have to grow, and they do most of their growing during sleep; so if they will not go to bed they will not grow properly. Sleep is more important for children than for anyone else, just for this reason, though no one can get on without it. Many of the people who grow up too small or weak, or poor in their minds, are people who did not sleep enough when they were children. Time was when older people were careless about children's sleep, but one of the happiest and best things for children nowadays is that their sleep is looked after.

WHERE WE GO IN OUR SLEEP

We do not go anywhere. We are still there, only we are not awake. That means that we are not awake to what is around us; but though we take no notice of what is about us, we are still there; and even while we are fast asleep we are often doing all sorts of things, or, rather, we think we are.

This is so every time we have a dream, and we have far more dreams than we remember when we wake. Long ago savages used to think that men merely went away somewhere when they slept, and dreaming was one of the reasons that made them think so; but now we are sure that that was a mistake.

Dreams do people all sorts of harm if they are not sensible about them; but we must be sensible, and not think that terrible things are going to happen. Dreams show that we have not really gone away, because they are almost always due to something disturbing us, and nothing could disturb us if we were not there, could it?

So slight a thing as the wind in the chimney, or a leaf tapping on the window-pane, may make us dream. But the commonest thing that disturbs us is our stomach. If we eat too much before we go to sleep, and especially if we eat things that do not agree with us, then in the night they disturb the brain, and make part of it wake up, though not so much as to make us know where we are. So, also, noises often make us dream because they disturb the brain. But sounds could not disturb the brain if we were not still there to hear them.

WHY YOU LAUGH

You laugh because you are "made that way." Perhaps you do not think much of it, but that is the real answer. It depends upon the way in which your brain and body are built. After all, you laugh when you are tickled, even though you may not be pleased, and that is really easier to explain. If a bright light suddenly strikes your eye, you shut it because your brain is made so as to make you reply in that way.

That is a simple way of replying. And laughing when you are tickled is really the same, only that instead of doing just one thing, you do a number of things all at once. You move many muscles of your face instead of merely moving the muscles of your eyelids. You also move the muscles that you breathe with, in an unusual way, and also the muscles that you make sounds with. It is this particular movement of all these muscles together that we call laughter, and it is really a reply to the tickling, just as drawing away your foot is a reply when someone tickles the sole of it.

WHY YOU CRY

You cry because your brain is made so as to act that way. We do not know why your brain should be so made, for though there is much use in tears when we are not crying, yet there is no real use in crying when we are hurt.

When people grow older they find this out, and usually they do not cry when they are hurt. The highest part of the brain—where people themselves really live—is the master of the lower part of the brain, and can order it to do things, and forbid it to do things, as it likes.

Now, it is the lower part of the brain that replies by crying when we are hurt, so that even the tiniest baby can cry perfectly. But when we grow older we tell the lower part of the brain that it must not do as it feels inclined to do, and so we stop crying.

WHY THE TEARS COME

There is no good reason why tears should come when you cry, but there is a very good and beautiful reason for the tears which we are really making all the time that we are awake, though we know nothing about it. You know quite well that every few seconds you wink both your eyelids at once. You do not do it on purpose, but you do it all the same. If you purposely stop doing it, as people often do when they stare at each other, your eye becomes very uncomfortable, and if you did not wink at all your eye would soon cease to work properly.

WHAT WINKING DOES FOR THE EYE

When the eye is open, the front of it is exposed to dust and dirt, and also the front of it is apt to get dry, and if it

did we could not see properly. Yet how is it that, though we never wash the front of our eyes, they are always clean? It is because we wash them every time we wink. Up above each eye, rather to the outer side, there is a tiny little duct called the tear-gland, and all the time we are awake this is slowly making tears. Then, when the front of the eye feels itself becoming rather dry, and perhaps a little dusty, it tells the brain, and down comes the eyelid for a second, with a tear inside it, and so washes clean the front of the eye. It is the most gentle and perfect washing in the world.

WHERE THE TEARS GO

Well, if you look at the inner corner of your lower eyelid you will see a tiny little opening. The tear runs down this and finds itself—where do you think? Now, I will give you a hint before I tell you. When you have been crying a great deal, do you not have to blow your nose? The reason is that the tears, as many of them as can, run down into the nose. All the time we are awake and not crying, this goes on, keeping our eyes moist and perfectly clean, and costing us no trouble. But when we cry we make far more tears than we need. Indeed, we make so many that they cannot even all run down into the nose, though many of them do. So, as there is nowhere else for them to go, and the eye itself cannot hold them all as they come pouring into it, they are spilled over the edge of the lower eyelid, and run down our cheeks.

But, though the tears, when we are not crying, are so useful that we could not do without them, and though the way they are made and used by the upper eyelid when we wink is one of the most beautiful things in the body, yet it is no use to make too many of them. Indeed, though the real use of tears is to make us see properly, you know very well that when you cry you make so many tears that you cannot see clearly at all.

WHAT WAKES US UP IN THE MORNING

We do not sleep in just the same way all through the night. To begin with, we sleep deeply. Now, it is good to sleep deeply. It makes us look well and beautiful, and people seem to have noticed this, since they call the first hours of sleep "the beauty sleep." But for some hours after this we sleep less and less deeply. We can easily find this out by noticing exactly how loud a noise is required to wake anybody up at various times in his sleep. And we find that when he has had nearly enough sleep he will be wakened by a little noise which, a few hours before, he would not have noticed at all.

Now, that is the sort of thing that happens when we wake. We have been sleeping less and less deeply for some time, and our brain has almost awakened of itself. Then there comes a sound or a light, or perhaps we move in bed and feel ourselves moving, and since we are already very nearly awake, the sound or the light or the feeling wakes us up. Of course, we live in a way that we have made for ourselves; but if we lived out of doors, as men did long ago, and as birds do now, it would naturally be light that woke us up at last. That is what wakes the birds up now. When the sun rises, and the light gets stronger, it wakes them up, though we are awakened by a noise.

DO OUR EYES DECEIVE US?

Sometimes we can learn from the deception of our senses. Our eyes see things for a tiny fraction of a second after they are gone. For instance, if you spin a little black and white disk you see circles instead of little bits of circles. That is because the eye goes

on seeing even when the lines are not there, and sees until they come round again. So if you take a card with a gate drawn on one side, and a man on a horse on the other side, and spin it, you seem to see the horse jumping the gate. It is this trick of the eye that is used in the biograph or cinematograph.

HOW A COAT KEEPS US WARM

A coat does not make us warm, but all that any coat can do is to keep us warm. Except when the sun is actually shining upon us, or when we are huddling over a fire, we make all our warmth for ourselves. There is no warmth in a coat or in any article of clothing. So, of course, clothing cannot make us warm—unless, indeed, we hold it in front of the fire until it is hot, and then put it on. Indeed, when you come to think of it, we make our clothes warm. Our clothes often feel quite cold when we put them on, but when we take them off they are warm, and they have received the warmth from our bodies.

HOW CLOTHES KEEP ICE COLD

The best way to understand how clothes keep us warm is to learn how to keep ice cold. Well, if clothing is simply something that keeps back heat, as a blind keeps back light, what would happen if we put some clothing on the ice? If we choose nice warm clothing—which simply means that it keeps us warm—ought it not to keep the heat from outside from getting into the ice?

Now, that is exactly what happens. If we take the warmest kind of clothing that we can think of, which is flannel, and if we wrap the ice up in flannel, we keep the ice cool, and prevent it from melting. Now, do you not think that is rather funny? When we want to keep ourselves warm we put on warm clothing, as we call it; and when we want to keep ice cold we put warm clothing on it. Would you not almost have thought that the clothing which made us warm would make the ice warm too, and so make it melt? Well, so it would if the clothing were really warm, like a hot bottle. But then, you see, there is no warmth in it at all.

WHY SOME CLOTHES ARE WARMER THAN OTHERS

You know what a thermometer is. It is something that measures how hot things are. Now, if you take a piece of flannel and a piece of linen that have both been in the same room for some time, and with a thermometer you try to find out how hot they are, you find that they are both just of the same temperature. But on a cold day you would rather put on flannel than linen, because, as we say, the flannel is so much warmer. Yet, according to the thermometer, the flannel and the linen are each just as warm as the other.

What is the meaning of this puzzle? It is simply that some things are better barriers to heat, and keep heat back better, than others.

WHY SOME THINGS ARE COLDER THAN OTHERS

In an ordinary room without a fire all the different things are equally as warm, because, if it has time enough, the warmth will spread itself over everything about it, running from anything that started warmer to anything that started cooler.

Yet if you go and touch several of the things in the room, one after the other, you find that they feel very different as you touch them. A thing like the fender will feel cold; the carpet will feel warm; wood would feel colder than the carpet, but warmer than the fender. Now, that is simply because these things differ in their power of keeping heat from running through them, just as flannel and

linen differ. The brass of the fender lets heat run through it quickly, but the carpet lets heat run through it slowly, and so we say that the fender feels cold and the carpet feels warm, just as a linen sheet feels chilly when we get into bed, while a woollen blanket feels warm. If a thing carries heat quickly away from our finger, it makes our finger cold, and we say that the thing is cold; and we call another thing warm in comparison with it, if that other thing, like flannel, only carries away the heat from our finger slowly.

WHAT HAPPENS WHEN ANYONE FAINTS

Fainting is really a wonderful thing. What happens is that the heart does not send enough blood to the brain, and so the brain stops working, and the person drops to the ground. When you are standing or sitting, your heart has to drive the blood upwards to your brain against the attraction of the whole earth, which tries to pull everything down. But directly the fainting person falls, the heart's task of sending sufficient blood to the brain is made easy, and so very soon his brain gets sufficient blood, and he "comes round," as we say. If his heart has not been actually strained he is all right again. So you see that the falling is Nature's method of "relieving the situation."

People who have not learned this try to raise up the fallen person, which is simply interfering with Nature's way and putting his brain in the worst possible position for getting the amount of blood it needs. The feet of a fainting person should be raised to allow the blood to more freely reach the brain.

DOES THE BRAIN NEED FOOD?

The brain is made of nerves and nerve-cells. These taken together we call nervous tissue, and we know that nervous tissue is more richly supplied with blood than any other tissue in the body, not even excepting the muscle tissue of the heart itself. The blood carries the food materials without which nerve tissue cannot act, and nerve tissue has practically no reserve at all of food supply in it. If the supply of blood is stopped for a moment, nervous tissue "gives out" sooner than any other tissue in the body.

A simple and wonderful little experiment will show you this for yourself. The screen or curtain at the back of your eye, which receives the rays of light from everything you see, is made of nervous tissue. It is packed with blood-vessels. If you shut one eye and look out of the other, and then press your finger firmly on the open eye (pressing on it through the lid), in a few seconds everything will grow quite dark. The eye is open and there is plenty of light, but it is quite blind. Move your finger away and in a second or two you will see again. The reason is that when you pressed on your eye-ball you prevented the blood running through the screen or curtain at the back of the eye, and after about two seconds, during which it was using up what it had taken from the blood, it could do no more, and your eye became blind.

WHY WE GET OUT OF BREATH

We know that if we treat the heart properly it never gets tired. But if we run very hard, or swim very hard, or do anything of that kind, we suddenly throw a great deal of extra work upon the heart. Now, so long as we are well, one of the most wonderful things about the heart is the amount of reserve power which it is able to call upon at a moment's notice. When we get out of breath we have already called upon this reserve power, and should take warning.

WHY WE HAVE LINES ON OUR HANDS

Some people have said that the use of these lines is to give us a better hold upon things, but probably that is not their real use. If it were so we should really have to say that they were scarcely worth having. It is much more likely that the use of these lines is to help the sense of touch in our hands and fingers, where touch is so very important. By making little valleys and ridges they increase the surface of the skin, and by going in different directions they help us to feel the kind of surface that anything has which we touch. The little endings of the nerves of touch are placed to the greatest advantage by means of these lines, and that seems to be the reason why they are so very well marked on just those parts of the skin where delicacy of touch is most important.

WHAT IS THE BEST CURE FOR FATIGUE

We must not take a large meal when we are tired, because we are not then fit to deal with food. We may take water, or lemonade, or oranges, because water, in passing through the body, always carries all sorts of poisons away with it and helps us to get rid of them.

But, above all, we must rest, and there is no kind of rest which can be compared with sleep. In general, the people who sleep best are those who work hard. The man who works all day in the fields usually has the best sleep in the world, far better than some unfortunate people who do little or nothing, and who may even take medicine to help them to sleep. Nature, the best of all doctors, has her own medicine to procure good sleep for every healthy person who works; and the most beautiful thing about tiredness, when it is the right fatigue that everyone should feel when he goes to bed, is that it produces in our blood just the very thing that gives us perfect and natural sleep.

WHY WE HAVE TEN FINGERS

Nature decided on five fingers, or toes, at the end of each limb very long ago indeed—ages before man appeared upon the earth at all. It is true that, at first sight, there seem to be many exceptions to this. We find only one obvious finger, or toe, for each limb in the horse, two for the pig, and so on. But the original figure was five. The hen, for instance, has only three and a half toes, and when we examine the skeleton of its wing—which is really its arm—we find three and a half fingers there. The chicken, as we see it, is the same. But if we examine the hen's egg before the chicken is ready to break through the shell, we find that it has five fingers, or toes, on the end of each of its four limbs; only the birds have apparently found that they could do as well with three and part of a fourth, so they have stopped developing the rest. We must go far below the the mammals or the birds, or even the reptiles, for the beginnings of the five-fingered or five-toed arrangement, and it is not till we study the still humbler creatures that we get to the real beginning. If we look at a frog we can see that it has five fingers and five toes just as we have. So we may say that it was the frog, or the remote ancestors of the frog, which decided ages ago that we should count in tens!

WHY ALL OUR FINGERS ARE NOT THE SAME LENGTH

It might be very difficult to answer this question if we had only the present use of the hand to account for; and it is a disadvantage to us that our little fingers and ring-fingers, for instance, are so short and weak, for this weakens our grasp for things, which is the principle purpose of which we use our hands. Also, this inequality of the

fingers in length and strength is a difficulty for the pianist and the typist. We therefore cannot hope to answer this question by referring to the usefulness of the hand for its present purpose. But we find the answer when we consider the history of the hand, and when we look at the fingers of many kinds of lower animals which have fingers more or less like ours.

We learn that our hands were originally used for standing and for walking, since we inherit them from "four-footed ancestors." If we put the hand on a table, as if we meant to walk on the tips of the fingers, I think we shall see at once what a well-balanced support it makes, just because the fingers are unequal in length —the middle finger the longest, and the short thumb and little finger falling behind and balancing the whole. We see the same thing in the case of animals that have three fingers—as the toes of the forefeet might rightly be called—and we can notice it for ourselves any day in the dog or the cat. This is only one instance of a very large number furnished by our bodies which helps us to understand why certain things, for which we can find no particular reason now, and which may even be inconvenient to us, are as they are.

WHY WE HAVE FINGER-NAILS AND TOE-NAILS

Perhaps we may think that, at any rate, there is a use for finger-nails, as we can use them to scratch with; but at the present day there is no explanation of finger-nails and toe-nails so far as use is concerned. If we turn to the past, however, we find the explanation at once. Our nails are all that is left to us of the things which the lower animals have and make great use of as claws and hoofs. We live by our minds, not by things like claws; and as we have not sufficient use for them, they have grown smaller and weaker in us—just as our teeth also have done, and our bones and muscles in large degree—until we have nothing left but nails.

Yet there is no doubt that they are really the same as the claws the cat uses for fighting and for climbing with, and for tearing its food; and the hoofs which the horse uses for walking upon. The ancestors of the horse had five fingers and toes, as we have, and a nail, or hoof, at the end of each; but all these except the middle ones have shrunk in the modern horse, until we find only one that reaches the ground, and the remains of another on each side. Occasionally we find a young horse born with three or even four toes. The horse's hoofs, then, are really the nails of its middle fingers and middle toes, and are very useful to it. They are made of the same material as our nails, and can be cut without pain, as our nails can.

WHY SOME PEOPLE ARE DARK AND SOME FAIR

The differences of color between various people are a good instance of those many differences which are due not to anything that happens to us in the course of our lives, but to something that is inborn in us, and usually derived from our parents. The children of two dark parents are dark, those of parents who are both brown-eyed are always brown-eyed, and so on. This way in which people resemble their parents is one of the most important things in the world, and the special name for it is heredity. We say that the thing in question, such as skin-color or eye-color, is hereditary.

All human beings may be divided into races by their color—the fair-skinned, the yellow-skinned, and the dark-skinned, and they are each apt to think the others ugly, especially

when these are accompanied by other differences. In America there is a great mixture of races, though nearly all belong to the fair-skinned family of mankind. Among us are a fairer and a darker race, and it is known that at present, owing to some reason we do not understand, the darker people are increasing and the fairer people becoming fewer. It is probable that ages ago differences in color depended partly on the amount of sun, darker people having coloring matter in skin and eyes which protects them from strong sunlight; but this is a question about which we do not know much yet.

WHY ONLY TWO SETS OF TEETH GROW

When we are born we have, hidden in our gums, all our first teeth. These twenty teeth are already completely formed in all their parts at birth, and only have to get through the gums in order to be seen. A baby gets its food by sucking and not by biting, and so it is better that its teeth should be out of the way at first, below the gums. Still deeper in the gums, below each of the primary teeth, and also farther back in the jaw than the primary teeth extend, there are little groups of cells, called tooth-germs, which will some day make the second set of teeth, usually called the permanent teeth, though they are often not as permanent as they might be. There are thirty-two sets of these little cells; and though none of them are teeth, or look in the least like teeth, they have in them the power of making teeth of the various kinds that we possess.

We should take very great care of the first teeth of children, brushing them, and having them filled if they decay, even though we know that they will fall out soon; because if they are neglected the tooth-germs underneath them are very apt to be injured, and when the new teeth come they will be irregular, or have thin, soft, crumbly outsides, which easily break away or decay. Now we see why a second tooth grows when the first falls out or is pulled out. But no third tooth will grow when a second tooth has been lost, because there is no other tooth-germ lying below the second tooth, as there is below the first tooth. Thus a third tooth cannot grow.

WHY ONIONS MAKE OUR EYES WATER

Our eyes are really watering all the time, or, rather, we are producing tears that pass over the eyeball and keep it clean. That is why we wink —to carry the tears that appear under the upper lid over the surface of the eye. These tears escape into the nose, as we know. We say that our eyes water when the tears form so quickly that they cannot escape quickly enough, because then we see them water. Onions give off something to the air which excites the ends of the nerves of smell in the nose, and also excites the ends of the nerves of touch in the eyeball and eyelids, and so sends a message to the brain, telling the tear-glands to make tears quickly, and then we say that our eyes water. There is use in this, for the rapid flow of tears helps to protect the eyelids and the eyeball from the irritant the onions give off. In people who, for some reason, cannot produce tears, such things as onions will make the eyes smart severely, because such people cannot protect themselves by making their eyes water.

WHY WE ARE RIGHT-HANDED

Some people think that babies are born with a natural tendency to use one hand more than the other, and that in the greater number of cases this is the right hand; but in a few—perhaps about six in a hundred—it is the left. They say it is not worth while to train both hands equally for everything—for instance, for writing

—as this would take too much time; and we could not become so skilful with either hand if we were taught to use both equally for everything.

But others think that the inclination shown by a child to use one hand or the other is determined by the way it is held to the breast by the mother when young. Some educators even favor teaching children to write and draw indiscriminately with both hands. This is called being ambidextrous. It is certain that there is very little in the old prejudice against the use of the left hand, for left-handed people as a rule write as well as others, despite the fact that our system of penmanship was framed for right-handed people.

WHY WE SHIVER WHEN WE ARE VERY COLD

There are more good reasons than one why we shiver when we are cold. The machinery of it, as we may say, is that cold, at first, rather excites and disturbs the nervous system, just as heat usually soothes it. We notice these contrary effects of heat and cold in the case of a warm bath and a cold dip. This does not say that shivering is at all the same thing as the feeling of activity we have after a cold plunge; but in each case the cold has been what is called a stimulant. But now we have to ask whether the shivering is of any use to us, or whether it is a wholly useless and purposeless thing; beyond any doubt it is possible to show that shivering serves the purposes of the body just as hunger does, and just as even fever often does, though we think of these as things rather bad in themselves. One good reason for shivering is that it makes us aware of cold as we might not otherwise be, and so we can protect ourselves. After the first stage of its action great cold sends the brain to sleep. Shivering perhaps serves to keep the brain awake and make it aware that something must be done.

HOW SHIVERING FROM COLD HELPS TO MAKE US WARM

A very good reason for shivering perhaps can be found. Whenever a muscle works, heat is produced; indeed, a very great part of the heat of the body is made in the muscles, which have been called "the fireplaces of the body." Shivering consists of small, quick, to-and-fro movements, sometimes almost quite regular, as when our "teeth chatter," of most or all of the muscles of the body. Now, though shivering often makes us aware that we are cold, yet it helps to keep us warm, for all these little muscular movements are producing heat. So we may say that when a person, by keeping still, refuses to work his muscles so as to keep warm, the brain takes the matter into its own hands and does what little it can by setting the muscles shivering.

WHY EVERYTHING SPINS ROUND WHEN WE ARE DIZZY

When anyone feels dizzy, and perhaps almost about to faint, his brain cannot properly control the working of his eyes. They may move round from side to side, perhaps independently instead of together, and so it may look as if things were spinning round. Another reason for dizziness has to do with a wonderful part of the body near the ear, and without which none of us could sit upright, much less stand, though few people have ever heard of it. This organ, which used to be thought to have something to do with hearing, really controls our balance. In some people it suffers from a disease, and these people constantly suffer from dizziness and a feeling that everything is spinning round and round.

As every one knows, we can make ourselves dizzy, and can think that

everything is spinning round, by turning round ourselves several times in one direction. This disturbs the organ of balancing, and this disturbance gives us the feeling. If you turn round the other way you put things right, by restoring the original state of affairs within the balancing organ. The name for the feeling that things are spinning round is vertigo; and vert simply means turn, as in such words as convert, invert, and others.

SLEEPING WITH THE BED-CLOTHES OVER THE FACE

Mothers sometimes get anxious about this, for they think—and quite rightly, too—that a child, or anyone else, should have its nose free when it is asleep, and not covered with the bed-clothes. But if they will watch a sleeping child, they will see that though often the child starts to go to sleep by covering its face up, yet always, when it is asleep or nearly asleep, the child's body will do the rest for itself, and the head will be moved until the nose gets free of the clothes, so that fresh air can get to it. So people who look after children really need not worry if children like to start the night with the bed-clothes almost over their faces. The child's brain, as soon as the child's self is asleep and cannot interfere with it in any way, will put things right.

WHAT ARE FRECKLES

What we usually speak of as freckles are spots of a yellowish-brown color which are seen on the skin of some people, especially after they have been exposed to strong sunshine for some time. They occur chiefly on the face, on the neck, and on the hands, because those are the parts of the skin unprotected by clothes. Some people are much more liable than others to have this coloring produced, and in some it disappears quite quickly, while in others it lasts a long time.

In all these cases the freckles are the result of the action of the sun on certain cells of the skin, which causes these cells to produce coloring matter, or pigment, which remains there for a certain time. There are cases, however, in which freckles do not appear to be caused by very hot sunshine or exposure, but which come naturally, just as the color of the skin itself is either fair or dark, according to the tendency inherited by the individual.

WHAT MAKES A DIMPLE

In order to understand a dimple, we should know the structure of the skin and what lies beneath it. In most parts of the body the skin, with its outer horny layer, and the inner living layer, which carries nerves and blood-vessels and makes the horny layer afresh from day to day, lies very loosely upon the layer of tissue beneath it. This is a loose layer, containing a certain number of fibers running in all directions, with fat-cells lying between them in healthy people—except under the skin of the eyelids, where fat is never found even in the fattest people. A few of these fibers are attached to the under surface of the skin, so that, though we can move the skin about very freely over what lies beneath it, there is, nevertheless, a limit to this movement.

But where there are dimples, as on the face, and often round such joints as the knee and the elbow, the number of fibers attached to the under surface of the skin is much increased, and they are rather short, so that the skin is depressed, or dimpled, at these points. We see what is really the same thing produced accidentally in the case of scars, which are often a little depressed below the general level of the skin because they are tacked down in the same way. But a scar differs from a dimple, as the skin over a scar has been lost, and is replaced by a new

thing called scar-tissue, while the skin over a dimple is true and healthy skin.

WHY DAMP AIR OFTEN MAKES US ILL

Damp air is often cold air, and the cold has usually been blamed for making us ill, though many facts prove that it is not blameworthy at all. There is one great difference between damp air and dry air, which accounts for the fact that people usually feel at their best in dry air, while many feel at their worst in damp air.

Water is always leaving our bodies by many channels, such as the skin and the breath. When the air is dry, this journey of water is readily made, but when the air is damp, it already contains a quantity of water, and so does not easily take up more, and the passage of water from our bodies is, to a certain extent, checked.

All life, as we know, is lived in water, and if life is to go on, enough fresh water must always be supplied to the living body, whether it be a man or an animal or a plant. When the passage of water is slow, as it is in damp air, then the processes of our lives are checked, and our bodies are apt to get choked up with things which would otherwise have been burned up and got rid of. This seems to be the real key to the effect of damp air upon rheumatism.

WONDERS OF ANIMALS AND PLANTS

WHAT THE BIRDS SING ABOUT

WHENEVER a child or a bird or anyone else sings naturally, it sings about its feelings. If you have no feelings you ought not to sing. Sometimes we sing just to show that we are brighter than other people, and when we do that we do not feel what we are singing, and everyone is glad when we stop. But the birds sing only when they must—when their feelings find their way out somehow. Then they try to tell the world how happy they are. The feelings that birds sing about are always happy feelings. When a bird is ill, or miserable, or unhappy, it never sings. Generally birds sing to express their feelings of love, and to call to their mates and their friends when they want company. At other times they sing simply for the joy of living, as the lark sings when he goes up into the sky. He sings for the joy of his nest on the ground, and for the joy of the light, and the joy of the air, and the joy of freedom. Perhaps the singing of the birds was the first music that was heard on the earth. But do remember the most beautiful thing about the birds' singing, which is, that they never sing that people may say "What a beautiful voice you have!" but always because they have some beautiful feeling which makes them sing.

WHY BIRDS FLY SO HIGH

If you stand on the top of a high building on a sunny day, you can see nearly over the city. The higher you go the more you can see, if your eyes are strong enough. These birds have very strong sight. Their eyes can see as well as ours would if we used a telescope.

The big birds look down from the great height at which they are flying, and they see many birds flying below. These birds below watch the earth. They see food thrown away by men and placed in the garden by children, and in a moment they fly down to get it. The bird which is right up in the air knows what they are doing, and swoops down quickly to take its share. These birds get a good meal. If they did not eat that food it would soon become bad in the sunshine, and make us ill; but it serves the birds for a good

dinner, and by eating it the birds save us from being ill. So we see how in all parts of the world Nature looks after her big family.

THE USE OF A MOTH

Hair and wool are rubbed off the thousands and thousands of hairy and woolly animals in the world, and, if this hair and wool were never destroyed, it would, in the course of many years, become a great nuisance. The moths eat this and so prevent us from suffering from such a nuisance.

But moths eat our clothes, you say.

Moths never eat the clothes which we have on, or the clothes which we wear regularly. If you have too many clothes to wear, you should give them to poor people who have not enough. So that moths teach us not to be greedy, not to hoard up things which other people would be thankful to have!

That is a lesson which not all of us would expect. Other unpleasant things teach us just as well. Those of us who have relatives in hot lands know how badly people there suffer from fever.

WHERE THE FLOWERS GO IN WINTER

The flowers of most plants can live and be useful for only part of one year, when there is plenty of light and warmth. When the summer goes they die. You know how the roses on a rose-bush die, but you know also that the rose-bush itself does not die.

In just the same way the leaves of most trees die at the end of the summer, but the trees go on living. When the flowers and the leaves die and fall, their death and fall is really a sign of life in the plant, or bush, or tree that bears them. If the whole bough of a tree is killed by something in the summer, the leaves will remain on it when the leaves of all the living boughs have fallen. There is really no waste or loss to a plant or a tree when its leaves and flowers die.

Before a leaf falls it changes its color, as we know, because the plant or tree is taking out of the leaf all the useful things that it needs for its own life. Then, at the base of the leaf, it forms a thin layer of something rather like cork, so that, after some of the useful things have been taken out of it, the leaf is left to die. There are still some useful things in the leaf, however, only they need something to be done to them before the plant can use them.

WHAT HAPPENS WHEN A LEAF FALLS

Many changes take place in the leaf as the summer goes away. When the leaf falls to the ground, there are waiting for it many tiny living creatures called microbes, which, as we say, make it decay. But this really means that the substance of the leaf is changed in such a way that it can be taken up by the plant from the soil and built up again into the plant when the spring comes. This is one of the most beautiful and wonderful things in Nature, and there is no greater lesson we can learn than that what looks like useless death and decay and waste is really nothing of the sort, but a living process that makes for more life.

You will say, Why should not the leaves and flowers live on all the year round, as they do in some plants for special reasons? But the leaf is made in order to use the sunlight, and in the winter there is not enough sunlight, and so the leaf would be wasting its time.

So the plant takes what it can use from the leaf and the rest of the leaf is changed, so that the plant can use that, too, when the summer is coming, and there is use for new leaves.

HOW THE MOSQUITO CAUSES FEVER

And now, after all these years, after many brave men have died from fever, a doctor has discovered that fever

there can be checked, and can be done away with. The fever is caused by the sting of a little insect called a mosquito. What we call the "midge" in this country is really one form of mosquito. In the hot lands this mosquito, when it stings, forces a deadly poison into the blood of the person it bites.

What the doctor does, having found out the cause of the fever, is to get rid of that cause. He finds that the mosquito lays the eggs from which the young ones are born in moist, swampy places. So the stamps are drained and the puddles dried up. Then the mosquito eggs cannot be hatched, and, there being no mosquitoes, men cannot be poisoned. The mosquito has taught men that they must be clean and careful in their homes.

How a spider spins its web

Great men say that nothing is more wonderful than the cleverness of the spider. The silk of which it makes its web comes from its body through tiny tubes, like the finest hairs. Many of them come out at the same time, but after leaving the spider's body they are all formed into one rope of silk, which is so thin that a hundred of them together are only as thick as a hair. The end of the silk is fastened to a twig or a leaf or a piece of wood. Sometimes the spider makes the fastening itself, or it may let the silk float from its body for the wind to blow it about until it touches something and clings there.

When both ends have been made fast, the spider is able to run down the thread and fix several more threads, perhaps twenty, all fastened to different points, but meeting in the middle. These are the cross ropes of the web. Then other lines have to be woven round and round these, making perhaps twenty rings. All this beautiful silk has come from the spider's body. The spider works hard and fast, and when the web is begun the work is finished in less than an hour. The web is then so strong that the wind cannot blow it away and the rain cannot break it.

The purpose of the spider's web is to catch insects, so the spider has still much work to do. Insects would not be caught in a web if they could walk

HOW NATURE HANGS HER BEADS UPON A SPIDER'S WEB

This is a spider's web covered with dewdrops. The spider makes its web with silk from its own body, which it spins into rings and threads until the web is complete. A web is so strong that wind and rain do not break it. There is nothing prettier than the spider's web with the hanging dew upon it.

or fly out of it, and to prevent their escape the spider covers all the web with a glue-like substance, which sticks to anything entering the web and holds it fast. We cannot see this glue with our eyes, but there are thousands of tiny beads of it dotted all over the spider's web.

How the birds find their way

We know that many birds fly away home over the sea to warmer countries when our summer ends, and return

when it begins again. This flight across the seas is called migration, and is one of the wonders of the world. We say that instinct guides them; but this does not tell us how instinct is able to do so marvelous a thing. When we cross the seas we are guided by those who have been that way before. We have charts and pilots and compasses, and even then we sometimes make mistakes.

But the birds have none of these things. They do not even take provisions with them; and we know that some of them become exhausted with their long flight, unsupported by food, while not a few are nearly dead. Yet, though this is so, the wonder of their flight, and their guidance, remains.

We can only guess that perhaps the older birds teach the younger ones, as happens with ourselves; and if anyone finds it hard to believe how they can remember, all we can say is that birds have wonderful memories for these things. The birds also have a wonderful sense of direction.

We know that some people can never find their way. They turn to the left when they should turn to the right, and so on. Other people scarcely ever make a mistake, even though they have been only once in a place before.

Probably birds and many other animals are even wiser than the wisest human beings in this respect. Perhaps if you bandaged a bird and "turned it round three times"—as when you play games—it would remember just how far and often it had gone round. But when they turn you round, you don't know whether you are facing the fireplace or the window. Your brain can't remember the turnings as the bird's brain does.

WHAT MAKES A BEE HUM

The humming of the bee and of so many other insects is not like the murmur of the seashell, which picks up sound like a telephone, but is made by the bee itself. You have never heard a bee hum when it was crawling—nor any other insect. This tells us what we might have guessed, that the bee's humming is made by the movement of its wings when it flies. The noise is not made by its voice-box, as when you sing, for the bee has no voice-box. But its wings move very quickly—a bird would "hum" when flying if its wings moved quickly enough—and as they move to and fro, or vibrate, or tremble, they set the air moving, and you know that waves in the air make sound when we hear them.

If the waves are too slow, as when you wave a stick in the air, or when a bird flaps its wings, we hear nothing. If they are too fast, as they are in the case of some insects, perhaps, and in other cases, like the scream of the bat we cannot hear them; or, to take the bat, some people can hear them, but many cannot. Thus there are many sounds we cannot hear, as there are many colors we cannot see. But the vibrations in the air made by the bee's wings are of a rate that is within the range of our hearing—if the bee is near enough—and so we hear a humming. No doubt you will guess that that word, like "murmur," is made to imitate the sound of which it is the name.

DID TAME FLOWERS ONCE GROW WILD?

Certainly all flowers did once grow wild, and all animals, too. There are certain kinds of flowers and animals which men have, so to speak, made by choosing the kind of thing they wanted and leaving the rest, and so gradually getting such things as the garden rose, the pouter pigeon, and so on. These are what we call cultivated varieties, but all of them, even the most curious and newest orchid, or pigeon, or breed of dog, have been made from wild or

natural forms; and, of course, before man started doing this, all flowers, all plants, all animals, were wild. Even now, if we are careless, our garden plants will return sometimes more or less completely to their natural state, and so will domestic animals. On the other hand, cultivated flowers may escape from a garden, as we say, their seeds being carried by insects or the wind, and may then appear to have grown wild. There is no end to what we may do by cultivating plants and flowers. Men used to try only to make beautiful forms, but lately they have tried to make useful ones, and have succeeded, especially in making from old kinds of corn new kinds which are far more valuable for human food.

DOES A WORM BREATHE UNDER GROUND?

Every living thing breathes, whether in earth, or on the earth, or in the sky, or in water. If it cannot get air it dies. The worm really has no trouble at all, for there is plenty of air and to spare in the earth anywhere near the surface. Of course, if you dig deeply into the earth, there will not be enough air for a thing like a worm, which needs a good deal; and you will find only living creatures, like some microbes, or tiny plants, which need very little air. Further down still you will find no living things at all. There is no life at all in the inside of the earth.

DO SEEDS BREATHE?

Seeds are no exception to the rule that every living thing must breathe. The seed gets its air, or, rather, its oxygen from the air, just as the worm does. So you must not plant the seed too deeply, or it will not get enough air, and then it will die. You may wonder that a seed should breathe, but that is because we always think of breathing as if the only kind of it were our breathing, with ribs and lungs.

The air in the earth, which enables plants to grow from seeds and trees from acorns, and keeps alive worms and insects and many microbes, is known as ground-air, and as its warmth depends on the warmth of the earth, it is very different at different times of the year. That is one reason why certain illnesses attack us at certain times of the year—because the warmth of the ground-air is just right for the growth of the microbes that cause those illnesses. Remember, there is air in the earth as there is in water.

WHERE THE SNAIL FINDS ITS SHELL

The snail makes its shell from its own skin. The same is true of the shell of the oyster, or that of the lobster. Our own skins, we know, can make things which are fairly hard, such as our nails; and it is also true that the hardest things in our bodies, our teeth, which are, or should be, even harder than the shell of the snail, are really made from our skin, which has been, so to speak, turned into our mouths so as to line them. There are really few things more wonderful than the way in which soft, living creatures, mostly made of water, are able to make the hardest things, like teeth and wood and shells and pearl, and so on. If we look very carefully at the skin of creatures like the snail, we can see how its outside cells are specially made so that they can gradually get harder and harder, until they cannot be called skin at all, but are really nothing else than shell. We can watch very much the same thing if we look at the cells at the base of our nails or the cells that make the horns of animals, and see how the soft skin is gradually changed.

HOW FLIES WALK ON THE CEILING

The reason, no doubt, is that the fly's feet, besides being just the least little bit sticky, are made like suckers,

and hold on to whatever the fly walks upon. Then, of course, we have to remember that the fly's body itself is very lightly made, just as a bird's body is, because both are meant to fly; and this makes it easier for a very little force to prevent the fly from falling even when it is upside down.

WHY SPIDERS DO NOT GET CAUGHT IN THEIR OWN WEB

It is the strength of the spider that prevents him from getting caught in his web, which is only made for catching creatures much weaker than himself. We know for certain that the spider can cut his web when he pleases, so that there is no fear of his getting caught in it. The spider is a wonderfully clever animal, but he is not brave. If an insect that is too big for his taste comes against his web, he will sit quite still in one corner and never move until it goes away, and sometimes he is so frightened that he simply cuts his web rather than get into difficulties with something that is more likely to eat him than the other way about. In this he is cleverer than some men, who make nets to catch other people and get caught in them themselves. In proportion to his size, the spider is a very strong animal, and it is really wonderful that he can cut his own web, for they say that in proportion to its weight it is one of the strongest things known.

HOW BIRDS KNOW HOW TO BUILD THEIR NESTS

It is by the power of what we call instinct. We human beings do very little by instinct; we have to learn for ourselves almost everything that we do. We cannot write or read instinctively, and if we are to learn well we must practice, and we must have help from older people to teach us. Only we have this advantage, that there is no limit to what we can learn.

The instinct of animals, however, shown in the spider's web or the bird's nest, or a thousand other things, is quite different. There is no learning at all. Many animals have to do a most difficult thing only once in their whole lives, and after doing it they die; and we know for certain that they have never seen any other animal do it. They have never learned, they have never practiced, and yet they do it perfeclty. That is the power of instinct; but the weakness of it is that it can do only what it is made to do, and it is for this reason that intelligence is so vastly superior to the best instinct.

WHY FISHES CANNOT LIVE ON LAND

Every living thing must have air or die. The fish comes out of the water, where there is very little air, into the air itself, and there it dies for lack of air. It is drowned on land for lack of air, and dies of what is called suffocation, just as you or I would be drowned in the water.

But why cannot the fish help itself to the air around it when it is put on earth? Why should it starve in the midst of plenty, like a rich man who has something the matter physically? The reason is, that in order to breathe air you must have lungs, or something like lungs, and the fish has none; while in order to get the air which is dissolved in water, which the fish does, you must have something quite different from lungs, which are called gills. The fish has no lungs, but only gills. We have no gills, but only lungs. Therefore, we die in the water and the fish dies out of it. If an animal had both gills and lungs, then it would be able to get air from the air or to get the air which is in water, as it pleased; and it could live both on the land and in the sea.

HOW WE CAN TELL THE AGE OF A TREE

In the case of some trees you can only guess at this, but in the case of

many you can tell exactly, because the tree makes a fresh growth every year under the bark, and as this differs rather in the earlier part of the year from the kind of wood which is made later, you can easily distinguish between one year's growth and the next. So when the tree is cut across—but that, of course, means killing it—you find that it shows a number of rings, one inside the other, and each of these rings corresponds to a year of the tree's life.

In the case of a man or a woman, the number of years he or she has lived need not make any difference or leave any mark. Some people are far younger at eighty than other people at thirty, for we do not live by the changing seasons of the year. But all plants do this in some degree or other, and thus they show the marks of their age. Another way in which trees differ from us is that, as long as they are alive, they go on growing, while we, of course, are quite different, and after the earlier part of our lives is past we never grow any more. Some trees live to be many hundreds of years old. even 1000 years or more.

WHY THE BARK GROWS ON A TREE

If the bark did not grow on the tree, the tree would not grow. The bark is a necessary part of the tree, and if you strip the bark off you will kill the tree. In the first place, the bark does one or two things which are useful but not very important. The outside of it is usually pretty tough, and has become more or less dead so that things do not hurt it, and it protects the living part of the tree inside. Often many animals and plants live on the outside of trees without doing them any harm, but that is really a very small thing. The inside of the bark is the most living part of the tree, we may say; not only so, but it actually makes the tree. All the growth of the tree in thickness is due to the making of the wood, and it is the bark, the soft living part of the inside of the bark, that has made all the hardest wood of the biggest and hardest tree-trunk. Also, there are channels in the bark through which the sap of the tree, its food and water, run, in much the same way as the blood runs in our own blood-vessels.

WHAT MAKES A CAT PURR

The noise a cat makes when it purrs is really a kind of talking, for it tells you that the cat has a certain feeling. It feels pleased and happy, and it says so in its own way, and no doubt another cat would know and understand what it felt, and very likely would feel pleased and begin to purr too, just as the company of happy people usually makes us happy. When a cat purrs, if you put your hand on it you can feel its whole body trembling. But when anyone speaks or sings—especially if he be a man with a voice low in pitch—if you put your hand on his chest you can feel him vibrate, or tremble, just like the cat. In the case of the man, we know that it is his vocal cords in his throat which he has set trembling, and they have set the whole of his chest vibrating. Whether anyone is sure what it is that the cat purrs with is doubtful, but the cat has vocal cords just as we have, and we may be sure it uses them.

HOW A DOG KNOWS A STRANGER

A dog has wonderfully good eyes, but it has a still more wonderful sense of smell. Our own sense of smell is so very feeble and unimportant that only after we have made a long study of animals can we realize how useful and delicate this sense may be. Thus a dog "knows a stranger" chiefly because the stranger has a strange scent. If the stranger wore the clothes of the

dog's master, then the dog would take him for his master, even though the stranger looked very different. After a time, very likely the dog might begin to feel uncomfortable, and act as if he thought something was wrong somewhere.

But, you see, every creature forms its judgments mainly by means of the particular sense which is best developed in it, and which it has therefore learned to trust best. We know people by our eyes, and though sometimes a man's voice may be exactly like the voice of a friend, yet we do not think that it is our friend if our eyes do not tell us so. Just in the same way the dog trusts his nose rather than his eyes, because his sense of smell is his best sense. Lastly, do not forget that it is because the dog has the wonderful thing called memory that he "knows a stranger." It is as if he said to himself, "This is not a smell I remember"—that is to say, it is a strange smell.

WHY THE LEAVES CHANGE COLOR

In the autumn the beautiful green color made by the sunlight in the plant changes and goes. It is not that the plant is dying, but that it is going to rest for the winter, when the air is cold and the days are short. After all, many animals go to sleep all the winter, and for the same reason. Hibernus is the Latin word that has to do with winter, and so we say that some animals hibernate. Well, we might just as well say that many trees hibernate, and since they are not going to use their leaves, they take out of them everything that will be useful. In doing this the tree changes the green in the leaf, and so we get various colors produced in the autumn.

WHY CERTAIN SEEDS COME UP AT CERTAIN TIMES

Young creatures come up, if they are plants, or are born, if they are animals, usually at the time of year which is best suited for their particular way of life. That is the general rule throughout the whole world, both of plants and of animals; and the case of the seeds which come up in spring, some sooner and some later, according to the way they are made, is really only the same thing. One exception to it is ourselves. All the year round, babies are born—Christmas Day and Midsummer's Day alike. The reason for this is that it does not matter what time of the year it is when a baby is born, because it depends, unlike a plant, not upon the weather and the particular amount of sun that is shining or the particular amount of warmth in the earth, but upon the love of its mother, and that it is the same all the year round. While, like all other living creatures, we depend partly upon the sun, and so on, yet, more than all other things, we depend upon the care of those who love us.

WHY ANIMALS IN SNOWY COUNTRIES WEAR WHITE COATS

The use of the white coat is to protect the animal from its enemies by making it difficult to see. If the animal keeps still it can scarcely be seen at all when its coat is the same color as the snow. But if it had a white coat in summer, when the snow goes, it would be easily seen, and so often its coat changes in summer, and the fur takes other tints, more like the color of the ground and the plants among which it lives. This is called protective coloring, and is very useful to many animals. But sometimes it happens that an animal which lives by catching others is also white in winter snow, so that it can get near its prey without being seen. Some insects do the same thing, and when they sit quietly among the leaves of certain plants no one can tell which

is insect and which is leaf, so the birds cannot find them.

WHAT BRINGS LIFE OUT OF DRY SEEDS

We may be sure that the life is there, or it would not come out of the seeds. The seeds are the children of plants that were alive before them, and part of their parents' life is in them. But it is quite true that a dried seed is very different from one which is sprouting, and it is fair to say that its life is resting or passive or suspended for the time. It is alive, we know very well, for it can be killed by boiling it or by a poison or in many other ways, and a dried seed may be dead or alive, as an egg may be dead or alive.

You will never be able to get a chicken out of a dead egg, or a plant out of a dead seed, but you will get a dried seed—provided it has not been killed—to sprout if you add water to it. It is because it is dried that it seems to stop living, which is not the same thing as to die. We know that it is not the same thing, for when it gets water it shows us that it is not dead. The chemical changes which are necessary for all active life must have water, if they are to go on. The water does not make the life come out of the dried seed, but reveals it. If you have injected a drop of poison into the seed first, then the water will fail to make it sprout, for it is killed.

WHY SOME PLANTS ARE ALWAYS GREEN

Though it is the common rule that green plants lose their leaves in the winter, when there is less sun for them to use, yet we must remember that the variety of life is infinite, and that one plant has one way of living which suits it, and another has another. Thus, some plants, which we call evergreen, develop a strong kind of leaf which lasts all through the winter, in spite of the wind and the wet, and uses the winter sun whenever it shines. Probably we shall find, at any rate in some of these cases, that the plant really belongs to a part of the world where there is plenty of sun in the winter, so that it is quite worth the plant's while to keep its green leaves all the year round. We must not think that evergreen plants are necessarily stronger or better than those whose leaves fall in the winter, for we know that the change and the fall of the leaf is not really a process of decay or of death, but a living process, meant to serve the life of the plant.

WHY BIRDS EGGS ARE OF DIFFERENT COLORS

We know, of course, that the differences in color depend upon the presence in the various shells of various coloring substances or pigments, and it is interesting to see how a particular kind of bird always produces the same kind of color in its eggs, just as it produces a particular kind of color in its own feathers. The particular kind of food the birds feed on, nor yet the particular surroundings it lives in, have likely much to do with the special color of its eggs. This must really depend upon the particular chemistry of the body of the bird. I do not mean that you cannot change the color of hens' eggs, for instance, by food, but you will never get a hen to lay a speckled green egg. The color of the shell is really as special to the particular bird as any of the things by which we know one bird from another.

USE OF THE DIFFERENT COLORS OF BIRDS' EGGS

If we compare the colorings and markings of a great number of birds' eggs with the places in which they are found, we discover that in a large number of cases the eggs are so like their surroundings that they are difficult to see at all unless we look

quite closely. For instance, a ringed plover's egg has the same general coloring as the sand on which it lies, and it is spotted over with black dots which look like tiny shadows. This makes it difficult to see the egg at all. In other cases the blotches or markings on the eggs look like an irregular piece of dark material lying, perhaps, on the beach. Thus, the eggs of the tern or gull sometimes look like stones or spotted pebbles, and, on the other hand, the stones themselves look so like eggs as to be easily mistaken for them at a slight distance; so that the reason for the coloring of eggs is no doubt to help them to be hidden from sight.

WHY A BAD EGG FLOATS AND A GOOD EGG SINKS

A fresh eggs consists of a mass of yolk, together with what we call the white of the egg, and this, being heavier than water, will cause the egg to sink when it is placed in water. But in an egg which has become addled or rotten, the yolk and white have split up into other things, and produce gases which cause the egg to be much lighter than it was before. In fact, such an egg does not weigh as much as an equal bulk of water does, so that if placed in water it will float and not sink.

CAN A FISH HEAR?

Although fishes are like some other animals in having no visible signs of ears, yet they have ears which conduct sound to the brain. Their organ of hearing consists simply of an internal ear placed inside a gristly capsule. In some fishes—as, for instance, the dog-fish—there is a fold known as the false gill, which is no doubt the remains of a real gill, but is now used for transmitting sounds to the internal ear. In the wall of the capsule which contains the internal ear there is a thin spot, and it is through this thin part, corresponding with what we call the drum of our own ear, that the sound is conducted. Thus, we see that in the case of some of the fishes there has been a change of function of an organ which was in the first place a gill, but has now become part of the hearing apparatus. In other words, it is a structure at one time used for breathing, but now used for hearing.

WHY FISHES DO NOT DROWN

All animals and plants must get air in some way or other in order to live; or, to be more strictly accurate, they must have a supply of oxygen, which is one of the gases in the air. Should this supply of oxygen fail, death must come, no matter whether it be from drowning or from any other cause. When a man is drowned, what really happens is that on account of his being so long under the water, his supply of life-giving oxygen has run short, and as he can only get it when he is in the air, he dies.

But this is not because there is no oxygen to be had in the water, for, as a matter of fact, there is quite a large amount of this life-giving gas dissolved in water, only human beings and animals breathing by lungs cannot make use of it. Their organs are only adapted for breathing air. The fishes, on the other hand, breathe by gills, not lungs, and the wonderful way in which gills are made enables them to extract the oxygen from the water. Being able to do this, they can live under water perfectly well. But if anything should happen to prevent the fish from getting oxygen from the water, or if something should happen to the water to deprive it of its oxygen, then the fish would be drowned, as would any other animal.

WHY A MOTH FLIES ROUND AND ROUND A CANDLE

No one can say what it is in the brain—or beginnings of a brain—of

the moth that decides it to like the light; and it is quite clear to everyone that this liking does the moth no good —at any rate, in the case of such a light as the candle. It may possibly be that it benefits the moth, and other creatures that behave like it, to fly towards light from darkness; and perhaps we should find this to be so if we knew enough of the lives of these creatures. But much study has lately shown that animals and plants can be divided into those which go naturally from darkness to light, and those which go naturally from light to darkness. Learned names have been applied to these habits—names which mean that the creature turns sunwards or away from the sun. Different plants and different parts of the same plant behave in similar ways; and if we notice the behavior of a baby towards a bright light we shall see that it is really like the moth. We find also that different creatures tend to move towards or away from other things besides light—such as heat, gravitation, electricity, and all sorts of chemicals and smells. Some grown-up people are like the moth—they move to the sunny side of the street; and others are like insects that usually live in darkness and fly towards it—they move to the shady side of the street.

WHERE PLANTS GET THEIR SALTS

The salts of plants are necessary for their own lives, and are very valuable for us when we eat the plants, or when we eat other animals which eat the plants. There are very few salts in rain-water; but the rain-water, when it becomes what is called soil-water, melts, or dissolves, into itself everything that can be melted from the earth around it. Exactly what these salts are must depend, of course, upon the particular kind of soil, and this is very important, for some plants require some salts and some require others; so the quality of the soil in various places decides what kinds of plants can or cannot grow there. The plant gets all its water and all its salts by its roots; and it can get no salts in the solid state, but only those that are dissolved in the soil-water. If we want certain plants to grow—such as grass or wheat, or even trees—we may often supply salts to the soil, so that they may be dissolved by the soil-water, and taken into the body of the plant.

WHY WOOD ROTS AWAY

Well, there are kinds of wood that will not rot away, even though they are kept in water. The ancient city of Venice is actually built on wooden piles buried in the shallow sea; and these have lasted for many centuries already. This wood does not rot because the things that make wood rot cannot attack it, and wood does not rot without a cause.

We shall begin to guess what it is that makes wood rot when we learn what is done to wood that must be exposed to wet and yet must not rot—for instance, the wood of which railway ties are made. These are often soaked with a chemical substance called creosote; and the particular property of creosote which makes it so valuable is that it is poisonous to microbes. So the answer to the question, in one word, is microbes; and wood will not rot if it is charged with something that kills microbes, or if it is made of stuff so hard and tough that even microbes cannot digest it; or if, as in the case of Venice, it is very good wood, and also protected from the kinds of microbes that can rot wood by being kept in salt water.

THE AGE OF ANIMALS

The prize for the land animals has to be given to the tortoise. This animal

lives, under favorable conditions, for between 300 and 400 years. One died in London in 1906 which was stated to be at least 350 years of age. Another reptile is the crocodile, which, given fair play in its native wilds, can live for 300 years.

It takes an elephant a long time to grow up, and it takes him a long time to wear out. Well treated, he should live to be a hundred. That is the age to which the eagle is supposed to live, but some people put down the age he may reach as 200 years. Even that is young compared with the life of the whale. This can be shown to last for 500 years.

In the following tables the extreme ages of things like the whale and eagle and tortoise are not given. The tables merely set out the ages to which certain animals often live.

THE NUMBER OF YEARS THAT BIRDS LIVE

Wren	8	Canary	24
Thrush	10	Crane	24
Robin	12	Peacock	24
Blackbird	12	Skylark	30
Hen	14	Sparrow	40
Goldfinch	15	Goose	50
Partridge	15	Pelican	50
Pheasant	15	Parrot	60
Lark	18	Heron	60
Nightingale	18	Crow	100
Pigeon	20	Swan	100
Linnet	23	Eagle	100

THE NUMBER OF YEARS OTHER ANIMALS LIVE

Rabbit	5	Horse	27
Sheep	12	Camel	40
Cat	13	Lion	40
Dog	15	Elephant	100
Goat	15	Crocodile	300
Cow	25	Tortoise	350
Pig	25	Whale	500

WHY BIRDS CAST THEIR FEATHERS

Feathers become worn, torn and broken, and must be replaced. The moulting of birds is similar to what takes place in other forms of animal life. Horses grow long coats of hair in winter which they shed in summer. Dogs cast their coats. Snakes cast their skins; crabs and other shell-fish cast their shells. If a crab lived always in one shell his body could never grow any bigger. At a certain time in the year his flesh becomes very watery, so he can draw his great claws through the narrow opening at the top of the shells in which they are enclosed, and he comes out of his shell almost as soft and pulpy as an egg in its skin with its shell removed. Birds are never left bare like this. They moult gradually. Some are so completely robbed of their strong feathers that they are glad to go into hiding until the new ones grow. They are then as defenceless as is the stag which has shed its mighty antlers.

WONDERS OF LIGHT AND SOUND

WHERE MUSIC COMES FROM

MUSIC is simply a special kind of sound. Other kinds of sounds we call noise. All kinds of sound are really the same, and they simply consist of waves in the air.

If you say you can scarcely believe this, because you have never seen them, the reply is that they are not meant to be seen but to be heard, and you have certainly heard them. These waves in air that we hear, though we cannot see them, are really wonderfully like waves in water, which we can see, though we cannot hear them. The air, after all, is not so very different from a great ocean of water. If there were two fishes living in the sea or in a lake, you can understand that if one of them flapped his tail he would make a wave of water which the other fish might feel.

When we speak or sing, or clap our hands, we make a wave of air very like that wave of water, and other people feel it in a particular kind of way, which we call hearing. After all, hearing is just feeling with our ears. These waves in the air move very quickly, and are very tiny, but they

are of many different sizes, even though they are all very small. The different kinds of waves make different kinds of sounds. If you make a wave in the air which is jerky and not regular, but just comes along "anyhow," then the ear, when it feels or hears that wave, does not like it, and that is the kind of wave that makes a noise. But if someone is singing, or if you strike a note on the piano, then the wave that is made is a regular and even one, and the ear likes it, and calls this a musical sound.

How the Piano Plays

The simplest way of understanding this is to take a piece of string and stretch it tight at its two ends. This piece of string is just like the wire inside a piano, which you hit when you strike a note; and the wire is stretched just as the string is stretched. When the piano-tuner comes, he goes over all the wires inside the piano to see that they are stretched just as much as they ought to be. Well, if you take this string and twang it, you can see it moving backwards and forwards, and can hear a low sound. When anything moves backwards and forwards like this, we say that it is vibrating, which simply means trembling. Every time it moves it makes a little wave in the air. If you make the string shorter, or if you stretch it tighter, it vibrates more quickly, and the musical note it gives out is a higher note, more like the treble of the piano. When we speak or sing, we make two cords in our throats, called the vocal cords, vibrate, or tremble, just like this cord or string that we can see vibrate for ourselves.

Why We See Ourselves in the Glass

The glass is made with a layer of quicksilver behind it. If that were not there, we should see through the glass as we see through the window. But the quicksilver prevents the light from going through and sends it back again. The glass and the quicksilver are both perfectly smooth and flat.

Now, we can see ourselves in any thing that is perfectly smooth and flat, and that is able to throw the light from our faces back to us. Of course we cannot see ourselves in what we call dull surfaces, because they keep the light; nor can we see ourselves in things with rough surfaces, because they do not throw the light back fairly, but scatter it in all directions. If you throw a ball against a perfectly smooth wall, and throw it straight, it will come straight back to you. If you throw it sideways, you know that it will come off the wall in a certain way. You could easily throw it to the wall so that it would bounce off to a friend standing further along the wall.

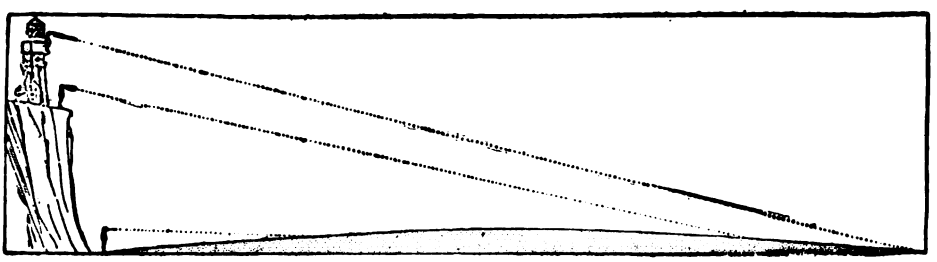
But if instead of a smooth wall you had a heap of loose stones to bounce the ball against, you could never tell where the ball would go after you had thrown it.

Now, when you stand opposite a good glass, the light from your face hits the glass and comes straight back, just as if it were made of a lot of little balls; but if you stand opposite something that is rough, the light comes back this way, and that, and the other, just as if you threw a handful of marbles against a heap of stones—and, of course, you cannot see yourself. The glass throws your image back to you as your body throws its own image on the ground in the sunshine. But on the glass your image comes back light, and your shadow on the ground is dark, because it is made by your standing in the way of the light.

What Makes the Colors of the Sunset

Now, when the sun is setting, its light does not come so straight down

upon us as it does when the sun is high in the sky, but, in order to reach our eyes, it has to pass through a long layer of air, just as if you stick a needle straight into an orange it does not have to go far through the peel before it gets inside, but if you stick it sideways in the orange it has a long journey through the peel before it gets inside. So the light from the setting sun passes through so much air, and all the dust and smoke, and so on, that is in the air; and all these take something out of the white light, and throw out what they do not take. The things floating in the air are of all sizes, and so we get many different colors in sunset. So it comes about that sunsets are often finer when the air is not pure, but has much dust in it.



WHY WE SEE FARTHER IF WE ARE HIGHER UP

The scientific explanation of this would be that "range of vision is determined by the altitude of the observer." In simple language, this means that the higher up we are, the farther we can see. That is because our world is a globe. Perhaps you can understand better how this is if you stand in front of a row of houses that form a bulging crescent. Stand close to one of the houses, and turn your head first to the right, and then to the left. You cannot see much of the row of houses—perhaps only a little bit of the house on each side of the one of which you stand in front. Step back into the middle of the road, and look again. Now you can see a good many more of the houses, but still not all if the row is long. Then go to the far side of the road, and a good many more will be found to have come within the range of your eyes.

To look for the horizon is much the same thing. The earth is round, and the farther we are above the ground along which we are looking, the farther we can see.

HOW FAR OFF IS THE HORIZON?

The word horizon is Greek, and is derived from the Greek word for a boundary, which is horos. Of course, we understand that the horizon is not really the boundary between earth and sky, but merely the boundary between them as they appear to our eyes.

This is a question often asked. As we stand by the seashore, the sky and the sea seem to meet. We can see a line which seems to be the end of the sea and the bottom of the sky. That is the horizon. Similarly, if we stand upon a plain of land we can, if there are no trees or houses in the way, see where the end of the land seems to touch the bottom rim of the dome we call the sky. That also is the horizon.

Its distance depends upon how high our eyes are from the level of the sea if we are looking across the sea, or from the level of the land across which we are looking if we are looking over a plain. The picture shows clearly how this is so. The boy standing by

the seashore is looking out upon the sea from a distance about four feet higher than the level of the sea—the height of his eyes from sea-level. He can see just a little more than two and one-half miles in front of him, and his horizon is just this distance away. The eyes of the boy on the edge of the cliff, on the other hand, are 100 feet above sea-level, and he can see about 13¼ miles off, and that is where the horizon is. Again, the top of the lighthouse is 150 feet above sea-level, and if a boy looked out on the sea from this point, he would see about 16¼ miles, and his horizon would be the same distance.

WHY WE CANNOT JUMP OFF OUR SHADOWS

Wherever we go, our shadows will follow, of course. We all know what makes shadows, but we do not all know what wonderful things shadows make. For instance, the moon is lighted by the sun's light; and sometimes the earth "gets in the light," as you do when you stand in front of the lamp by which someone is reading. So the earth prevents the sunlight from reaching the moon, and throws a round shadow, which we can see across the moon as the earth gets in the way. This is an "eclipse of the moon."

Then shadows make strange things when they are thrown far away. The shadow of your hand becomes very big if it is thrown on a wall far off. And sometimes the shadow of a man's body may look like a strange giant and frighten the man who is making it! There is a mountain in Germany, called the Brocken, nearly a mile high, where a man's shadow is sometimes thrown on the clouds.

WHY THE SKY IS BLUE

This was found out last century by John Tyndall. You would never guess the reason. The sky gets its light from the sun. When the sun is away, the sky is dark. Therefore, the blue of the sky must be somehow thrown to our eyes from something in the sky which keeps all the other colors in the white light of the sun, and throws back the blue, and that is what happens.

The sky is filled with countless tiny specks of what we may call dust. These are of just such a size that they catch the bigger waves of light, which make the other colors, but throw to our eyes the shorter waves of light, which make blue. If you could do away with all the solid stuff in the air, the sky would be dark, and all the light of the daytime would come directly from the sun. Skylight is reflected sunlight, but only the blue part of it.

WHY IT IS DARK AT NIGHT

If you take a ball and hold it near a bright light the half of the ball next to the light is shone upon, and the half of the ball away from the light is dark. If you mark a spot on the ball, and then turn the ball round and round like a top, that spot will be shone upon half the time and will be in the dark the other half of the time. We live on a big ball called the earth, which is always spinning round and round, and it is shone upon all the time, day and night, by a bright light called the sun.

The place where we live is like the spot on the ball, and as the great earth-ball spins, part of the time we are on the side next to the sun and part of the time we are on the side away from the sun. When we are on that side it is dark at night, but while it is our night it is daytime for the people who live on the other side of the ball. However dark it is where we live, the sun is always shining somewhere, and the earth is always traveling towards it or away from it. The sun does not

come to the earth, but the earth comes into the sunlight. If you think of the ball and the light you will understand that, however dark it is, the earth will soon carry us round into the light again. Have you ever heard one of the most beautiful lines in all poetry: "There is a budding morrow in midnight," meaning that every night a day is being born.

THE NOISE LIKE WAVES IN A SEA SHELL

This pretty idea is only just a poets' fancy, and nothing more. The truth is, we only imagine a likeness between the sound of the shell and the sound of the sea; though I quite admit that it is easy to imagine, and that we may forgive the poet who said that the shell is "Murmurous still of its nativity"—its place of birth. Murmur is a good word for this, made on purpose to imitate the sound.

Really, then, the shell is one of those things which can pick up and make stronger certain kinds of sounds. The wooden part of a violin does this: if you take it away and play on the strings without it they make a feeble, thin, unpleasant tone. These things that make sound resound are called resonators. The body of the violin is one, a sounding-board is another, and a shell is a third.

THE SOUNDS WHICH THE SHELL PICKS UP

"The shell," you may say, "makes a murmur even when everything is quiet; surely the sound is made within itself—it murmurs still the sounds of its birthplace." The answer is that really it is never quite quiet, and that the shell picks up sound so slight that we do not hear them at all without the shell. This has been shown in a new way. A sound-proof room was built. People inside it heard their own hearts beating, and so on. But there were cut out of the room all the tiny noises that usually go on, and when a shell was held to the ear nothing at all could be heard. The shell is only a telephone, and if no sounds come for it to resound, it is silent. But the beauty of the poet's idea remains; and it is true as a picture of what happens with men and women, and their remembrance of the places and people of their childhood.

WHY A NOISE BREAKS A WINDOW

Noise is an irregular wave in the air—which is a real thing, and has weight and power, remember. A wave of air may break a window exactly as the wave in the sea will break a breakwater, though, as the name tells us, the breakwater will break the wave, as long as that wave is not too strong.

If you think a moment, you will see that every time a noise gets through a shut window it shakes the window. If the noise is coming in from the street, the air outside is thrown into waves which pass through it until they strike the window, and shake it; then the window shakes the air inside the room in exactly the same way as the air outside shook it, only perhaps not quite so strongly. And so the noise reaches you, just as if you had heard it outside, only not quite so loud. Well, plainly, the noise has only to be loud enough—that is to say, the waves in the air have only to be big enough—to shake the window more than it can stand, and then it breaks. Now, since air is a real thing which has weight and power, the truth is that a noise breaks a window just as does a baseball.

WHY THE KETTLE SINGS

Everything that sings, sings really for the same reason, because it is set vibrating. When you sing or speak you make the little cords in your throat tremble, and when a kettle sings we may be sure that something is vibrating somewhere. This sets the air round it vibrating, and if it

vibrates quickly enough we can hear it sing. If you only had a stick in your hand, and could turn it quickly enough in the air, you could make the stick sing.

Now, kettles do not always sing quite the same tune, and that depends upon a number of things; but at any rate we can understand that, as the water gets hot and begins to boil, it is turned into water-gas, or water-vapor, and it has to force its way out through the spout, and past the lid of the kettle. As it does this it sets various parts of the kettle trembling, and so the air is made to tremble, and so the drum-head, or window, in your ear is made to tremble, and your brain feels this, and you say the kettle is singing.

It is the pressure of the gas coming out that sets the kettle trembling. When you speak or sing you nearly close your throat, and then squeeze the air in your lungs through the small opening; and it is the pressure of the gas that sets your vocal cords trembling. So the kettle sings just as you do.

WHY LIGHT SEEMS RED WHEN WE SHUT OUR EYES

Eyelids cannot stop all light from coming through to the eyes—that is to say, they are, in a small degree, transparent, and enough so for the sunrise to waken the birds, even though their eyes are shut. Yet, when you look at the window with your eyes shut, what you see—very faintly, but still you see it—is a red color. Can you guess why this is? It is because the light that is able to pass through your eyelids has to pass through the red blood which, of course, is always in your eyelid. Now, this red blood keeps all the other colors that go to make up the white light, but lets the red color come through it, and that is why we see red with our eyes shut in the light. If our blood were green, we should see green.

CAN WE SEE EVERYTHING?

There are just two sorts of people in the world—the foolish, who think they see all there is to see, and the wise, who know they do not. This applies to seeing with the eyes of our heads, and to seeing with the eyes of our minds—which you mean when someone explains something to you, and you say: "Oh, I see!"

One of the greatest and wisest men who ever lived said that the highest knowledge a man could have was to know that he knew nothing—nothing, that is, compared with all that there is to know. For this, and other great sayings, this wisest of men—his name was Socrates—was executed by his fellow-citizens over 2000 years ago.

Even with actual seeing, and the best and brightest eyes, we see only a little of what is there, and usually see only its surface. That is why insight is such a good word for wisdom: it means that the eyes of a man's mind see into a thing. Then our eyes see only certain kinds of light. There are other kinds, which are darkness to us, yet we know that they can be seen by the eyes of ants, and also they can be seen by the lifeless eye of the camera, which has seen for us hundreds of thousands of stars that our eyes have never seen, and never can see.

DO WE SEE WHAT IS NOT THERE?

Besides not seeing most of what is "there," our eyes often see—or think they see—what is not there. Some of the most remarkable events in history have been due to mistakes of this kind. One of the great duties of the reason is to judge of what the senses, like eyes and ears, tell us, so that we shall not be deceived, or so that we shall learn all the more from our mistakes.

DOES LIGHT WEIGH ANYTHING?

If light were made of a shower of little sparks or specks, as Newton thought, then each of those must weigh something. Light, however, we know, is not matter at all, but a wave in the ether. So it has no weight. But that is not the whole story. Our study of light teaches us that it ought to have the power of pressure, which, in its results, comes to the same thing as weight. Thus, if you have a balance, and equal weights on each side, and then make a beam of light play down on one side, it ought to press down that side of the balance, just as if a weight had been added.

This is what was taught by a noted scientist, Clerk-Maxwell, many years ago, before this pressure of light had been proved. He foretold not only that there must be such pressure, but how much it must be. We can now show that pressure by experiment, and have found that his prediction of its amount—though he had never seen it at all—was right.

It is possible to prepare what is really a balance delicately hung on a thread of quartz, and to see that when a ray of light plays on one side of it, at once the balance turns as if you had touched it with your finger, or thrown something against it. This pressure, which is so like weight in its results, though it is not weight, is sometimes called light pressure. But it is common not only to the light that we can see, but also to the other radiations or rays in the ether which we cannot see. The proper name for it, therefore, by which it is now known everywhere, is not light pressure, but radiation pressure.

WHY THE SNOW IS WHITE

You might have asked also why is foam white when a wave breaks. In both cases we know that we are dealing with water, and yet, instead of being transparent, which means that it lets the light through, it is white. We understand at once when we find out what snow and foam are made of, or rather, what is the state of the water that makes them. In the case of snow, the water is frozen and forms tiny little crystals of beautiful shape.

These all lie loosely together, forming the snow, and though, if you could take one of them by itself, light would go through it just as it will go through a piece of clear ice, or many other crystals, yet when you have a heap of crystals lying together, all turned different ways, they throw the light back in all directions, just as salt does. They do not keep any part of the white light that falls on them, but throw it all back, and so snow is white. But, of course, if you have colored light falling on the snow, then the snow throws back that same color, and this gives some of the most wonderful sunset effects upon snow-covered mountains.

WHAT CAUSES A LIGHT TO BE YELLOW

What we call white light is made up of a vast number of lights of different colors all mixed together in just such a proportion that our eyes call it white. It is almost as if every note on the piano were played at once—with the difference that if this were done our ears would call the sound unpleasant; whereas, when our eyes see all these different kinds of light at once, the result is pleasant. The reason why it is pleasant is that this is the kind of light which the sun gives, and so through long ages our eyes have become suited to it. Now, yellow is just one of the colors that go to make up white light. The waves that make it are quite well known, and are rather low down in the scale of color, like a low note on the piano; while blue, for instance, is high up in

the scale, like a high note. Though we say that the sun gives white light, yet really there is rather too much yellow light in sunlight for the result to be quite white.

WHAT MAKES THE RAINBOW

The rainbow is made by drops of rain; it is due to the reflection of sunlight from drops of water hanging in the sky. As the sunlight passes through the raindrop, and is reflected from the inside of the back of the raindrop, it is broken up into its various parts, which correspond to the various colors of the rainbow.

White light, we know, is a mixture of many colors. The light waves corresponding to these colors differ in the extent to which they are bent by passing through such a thing as a raindrop, and so, when they come out of it, they are sorted out, so to speak; and what was white light on going in, comes out as a band of several colors. Thus, what we see in the rainbow is really a natural spectrum of sunlight—the light spread out in a band of the various colors that make it up.

WHERE THE RAINBOW ENDS

As we trace the rainbow down on each side it seems to touch the earth, and there are stories of children who have set out to find the end of the rainbow. But the rainbow ends nowhere, for it is a mere appearance in the sky, due to tiny drops of water, and it "ends," if we are to use that word, simply where the drops of water end that are so placed as to reflect the sunlight in this way to our eyes. Really no two people see exactly the same rainbow. They could not do so, unless their eyes were in the same place. And as we move, the bow we see moves with us.

WHY SPINNING LIGHTS MAKE RINGS

When black and white have an equal chance, the white conquers the black, because the white is something and the black is nothing; black is simply no light.

The disk of a black and white top looks all white when you spin it under a bright light, because your eye remembers the white when the black comes round, and remembers it till the white comes round again! And the black lines make black circles because they catch the eye and the eye remembers them in the same way. It is the eye's way to see a thing for about one-fortieth part of a second after it has gone! If you spun the disk in the dark as fast as ever you pleased, and then had a sudden light that came and went very quickly, you would see the spinning disk exactly as if it were still—half white, half black, and with bits of circles instead of whole ones. In some lights, too, we see colors, probably because the eye gets confused and invents them.

A whole roomful of people may be astonished at this experiment. The eye sees what is really there, and then the light goes out, and so, though the eye goes on seeing for a little after the light goes, it gets no chance to have another look, and so do what it does when the light stays on. This proves that nothing happens at all to the disk to make the change when it is spun. It is the way the eye sees that deceives us. The eye goes on seeing one color even when another has come; it mixes them—and then we see a new color made of the mixture!

WHY THE CENTER OF A GAS-FLAME IS BLUE AND THE OUTSIDE YELLOW

The color of a burning or a hot thing depends largely on the temperature of it. A white-hot poker is hotter than a red-hot one; and a white-hot star like Sirius is hotter than a red-hot one like Aldebaran or the sun. The outside of a flame is far hotter than the inside, and gives out a brighter light in consequence—like a hot star

or a hot poker. The color is due to "red-hot" particles of carbon.

Now you will ask why the inside of the flame is colder than the outside, and the answer is easy. The outside of the flame is the part next the air—next the oxygen—which causes the burning. The inside of the flame has to be content with the very small amount of oxygen which gets to it, still unused, through the outer part of the flame. Where the burning is fastest and most complete, there the heat is greatest, and therefore the outside of the flame is hottest.

Why Telegraph Lines Hum

Anything that is stretched is apt to be thrown into vibration, or made to tremble, by the force of the air blowing against it. If it vibrates so fast as to produce the air-waves that our ears can hear, then that is what we call sound. This is what happens to the telegraph wires when they hum; and if we put our hand on the telegraph pole we shall feel that the wires vibrate strongly enough to set the whole pole trembling, too. If we think of the way in which our own voices are produced we shall see that the telegraph lines hum in exactly the same way as we hum ourselves. Something stretched, in each case, is made to tremble. When the air is quite still, you will not hear the telegraph lines humming.

Why the Sky is Dull When a Storm is Coming On

The light of day is almost all due to the sun. The stars are shining, of course, as they do all the time, but they are so far away that the light of all of them put together counts for nothing compared with the sun; nor does the light of the moon count for anything when it happens to be up during the day. Thus we may say that the light of day is due to direct sunlight and to skylight, which is sunlight reflected from the sky—that is to say, from the air. When a storm is coming on, clouds gather, and these clouds are thick and dense, so that they cut off the light of the sky, and so we say that the sky is dull. If we went up in a balloon above the clouds, we should find ourselves in brilliant sunshine, even when it was almost as dark as night to the people on the earth below.

Why We Have to Develop Photographs in a Red Light

We know that white light is a mixture of light of all sorts of colors—red, yellow, green, blue, and so on. Some of these lights of various colors have one kind of power, and some another. For instance, red light has far more heating power than violet light, which has practically none at all, while red light will soon show its power on a thermometer. Now, the kind of light that has the power of causing chemical changes, which is the light we see by, and the light we photograph by, is mainly violet light, or the violet part of white light. We can see, in a way, by red light; but red light has practically no influence on photographic plates. We may say that photographic plates cannot see red light, and so we can use it to develop them by, without fearing that the photograph of our faces or the walls of the room will be printed on the plates.

What Colors Stagnant Water

When water becomes stagnant various forms of life grow on its surface. Pure water alone will not support life; there must be some other things in the water, and perhaps a fatty or oily layer on the surface of it, before these things—mainly microbes—will grow. Their growth covers the surface of the water with very thin layers of matter from which the light is reflected to our eyes when we look at it. But it happens, as in many other cases, such

as a soap-bubble or mother-of-pearl, that the light is partly broken up as it is reflected from these thin layers, or as it passes through them if we were to see the water from below; and so the colors are produced. The reason is that the waves of light, as they return, some from one layer of the surface, some from another, interfere with each other, and the proper name for this is the interference of light.

WHY A POP-GUN POPS

The "pop" of a pop-gun is a sound, and all sounds are waves of a particular kind produced in air or in other things. If they are to be what we call sounds they must be the kind of waves that our ears are able to hear, and these are special, differing from waves of wind, because they are very short and quick.

The question, then, really is: How does the pop-gun cause the kind of air-waves that we can hear? And the answer is that air inside the gun is compressed and then suddenly released, when the gun goes off. As it is released, it naturally expands or spreads itself out again to fill the space it filled before it was compressed. This means, of course, that it gives a quick push, as it expands, to the air on all sides of it, and so it starts the wave of air, which spreads out in all directions, from the point where it started, and reaches our ears. The kind of wave is one which our ears hear as a very short, sharp sound. It is short because the cause of it acts for only a very short time, and the sound of it is best represented by the word "pop."

WHAT MAKES THE LOUD NOISE WHEN A GUN IS FIRED

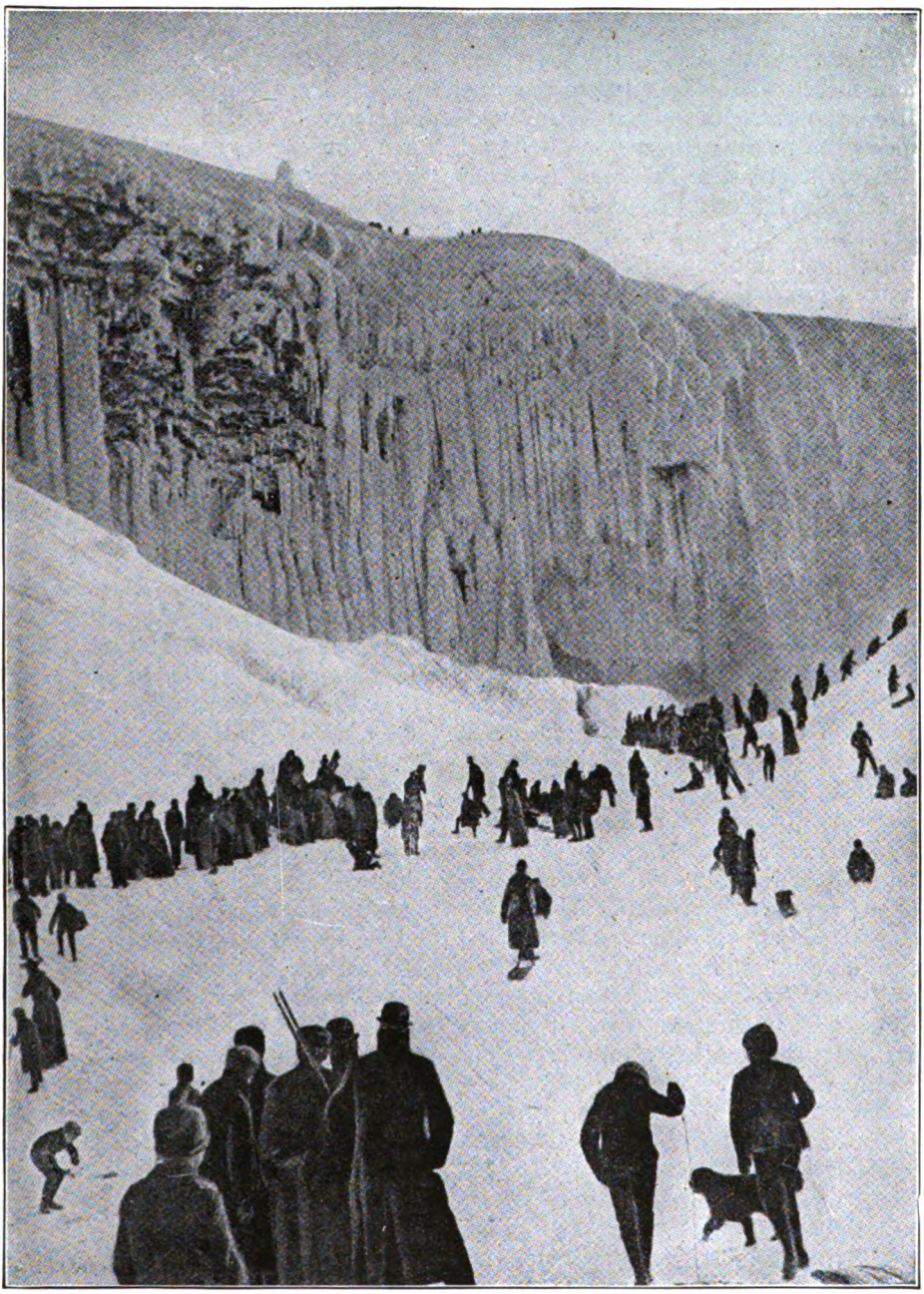
This noise also is due to an explosion, the sudden expansion of a compressed gas, as it escapes into the air from the space in which it was confined. Now, in a pop-gun, the gas that is compressed and then allowed to expand is air which already exists as air. But there is no air or any other gas in a cartridge, and the question is: Where does the gas come from that makes the noise and fires the bullet when a gun is fired?

What happens is that we suddenly burn a powder which we have prepared of materials such that when they are burned a large quantity of gas will be produced, and it must be produced very suddenly, if the full explosive power is to be obtained. We have another great advantage in trying to make this kind of explosion, as we have not when we fire a pop-gun. That is that the gases produced are exceedingly hot, for they are heated by the burning which makes them. A hot gas naturally occupies a great deal of space—far more than a cold gas, and so when we fire a gun we suddenly produce a great quantity of hot gas in a tiny space, which is not nearly sufficient to hold it. If this were done in a closed box it would burst the box, but in the case of the gun we have prepared a way out for it—only that we put a bullet in the way. Out comes the gas, driving the bullet before it, and as it expands it starts the wave of sound we hear.

WHY HOUSES SEEM CROOKED WHEN WE LOOK ABOVE A STREET FIRE

Light is always bent in some degree by the various things through which it passes—as when it passes through the air to our eyes from a star, or as when a stick, half in water, seems to be bent. Now so far as light is concerned the air is different according to its warmth. Warm air is less dense than cold air, and when light passes from one to the other, in either direction, its path is more or less bent. So when we look at the houses through the hot gases that rise from a watch-fire, the light, as it travels from the

REMARKABLE SPECTACLE OF A FROZEN CATARACT



This is one of the most wonderful things ever done by Jack Frost. It is a picture of Niagara in winter. No man's hand, no machine ever made by man's hand, could stop the mighty rush of Niagara over the cliffs; but winter does it, and silently ends the roar of the waters. When winter comes parts of the great Niagara Falls are often frozen over, and then the sight is one of the most beautiful in the world. Part of the frozen falls is shown in this photograph. Imagine enormous icicles, far thicker and taller than the pillars in any cathedral, all sparkling like diamonds in the sunshine. The frozen spray covers all the rocks and trees near the falls with wonderful hoarfrost, looking like beautiful moss and ferns of glittering white

houses to our eyes, is bent in passing from the cold air through the hot gases, and is bent a second time in passing from the hot gases through the cold air again.

Also, as the fire does not give off the same quantity of gas at every moment, the light is bent in different ways, and not only do we see the houses crooked, but they seem more or less crooked as we keep on looking at them. This bending, or breaking, of the rays of light as they pass from one thing to another is called refraction, which simply means breaking, and is very important in every way. Just as you see the houses crooked when you look at them through the gases from a fire, so we see all the stars crooked when we look at them through the air. The light from the stars is bent as it passes through the air, and so we do not see stars where they really are, but always a little distance from the real place, because of the refraction of their light.

WONDERS OF AIR, FIRE AND WATER

WHY WE CANNOT SEE THE AIR

THE reason why we cannot see the air is that it is transparent, like glass—that is to say, it lets light go through. It affects the light in some ways; for instance, light coming to the earth from a star is bent a little as it travels through the air, so that we never see the star where it really is. But directly we change one part of the air as compared with the air around it, so that it bends the light a little more or a little less, then we notice something.

In a sense you can see the air moving sometimes above a hot gas-jet or a field on a hot summer day. Also it is quite easy to change air so that you can see it in another way. We can make it cold so that it becomes like water, we can see it as you see water, and we can even freeze it so that it looks and can be seen just like ice. The air, fortunately, has no color in itself, so it does not alter the color of the light passing through it—which would mean altering the color of things.

WHAT THE AIR IS MADE OF

The air is a mixture of several gases, and these are all colorless and transparent. Among the gases in the air are carbonic acid gas, which we give off when we breathe—and which is food for plants—and also a small amount of various other gases found only a few years ago. Most air also contains not a little water in the form of a gas or vapor. But all these taken together do not amount to very much. Very nearly the whole of the air is composed of two gases only; about four-fifths are made by a gas called nitrogen, which is very valuable to plants and therefore to us, and the remaining fifth is made by the wonderful gas, oxygen, by which we live every moment of our lives.

The air of crowded indoor places, or the air that you will find in a bedroom in the morning if only a single person has been sleeping in it all night with closed windows, is very different from fresh air or open air. It has the same things in it, but it has a great many other things; it has too much carbonic acid gas and too little oxygen, and it has all sorts of poisonous gases which the sleeper has given off in his breath and from his skin.

WHAT A DEWDROP IS

At night when the dew comes, great dewdrops frequently hang upon a spider's web stretching across the trees. Those tiny beads of water look very simple, but it took wise men

hundreds of years to find out what they are. Then they found that a dewdrop is part of something very important indeed. There is in the air a great deal of moisture, which cools the rays of the sun so that we are not burned on a hot summer's day. At night, when the earth passes out of the sunlight, the earth lets out the heat that it has stored up by day, and the moisture causes the heat to escape slowly. If it did not the earth would suddenly become so cold that we should be frozen to death in a single summer's night.

Well, in the evening, when the earth begins to give off its rays of heat, the moisture in the air drinks in the rays, so that the moisture becomes warmer than the earth and the grass and the flowers, from which the heat rays have come. The grass and the flowers become very cold after losing their heat, and as they grow cold they chill the moisture near them. The moisture, when it becomes cold, turns to real water and falls towards the ground like rain, and the blades of grass, or the leaves of trees, or the spider's web, catch the drops as they fall, and the water, trying to keep itself together as much as it can, gathers into tiny beads.

These are the dewdrops.

WHY THE SEA IS SALT

It is the rivers that make the sea salt. The sea was first made by the water that was in the air falling into all the deep places on the earth. That was the first rain that ever fell, and it was quite fresh—that is to say, there was no salt in the water, but the first salt in the sea was taken directly from the crust of the earth, and later added to by rivers. There are all sorts of salt in the earth, and as the rivers run into the sea they take the salt out of the earth they run over and carry it into the sea, although when the sun draws up the water again and makes the rain it does not suck up the salt with it.

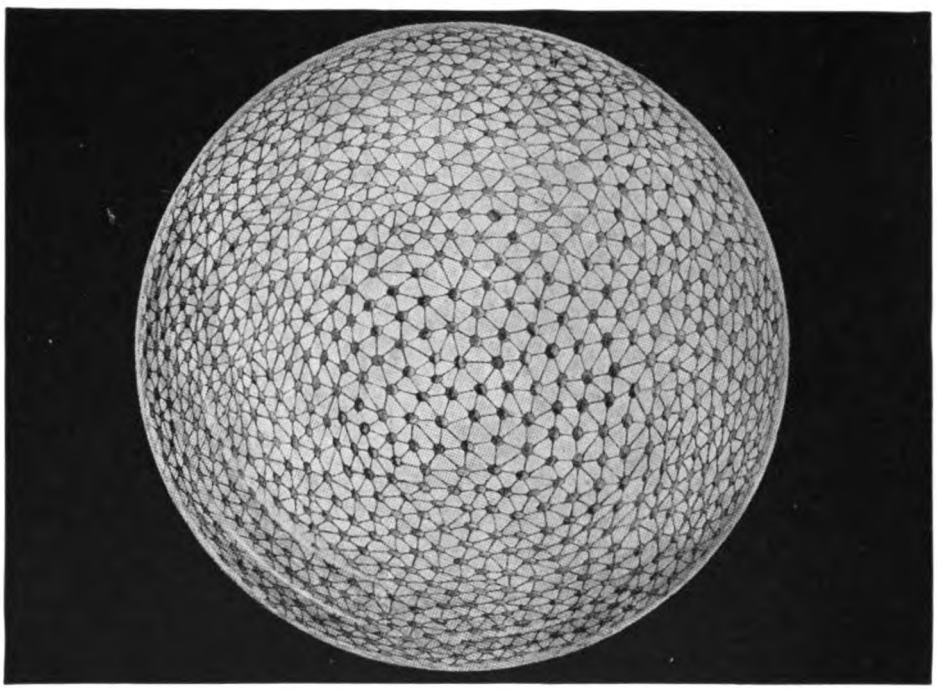
You have just learned that it is the water drawn up by the sun that makes the rivers, and so the rivers start with fresh water; but by the time they have reached the sea they have taken quite a lot of salt, which they add to the salt already in the sea. So from day to day, and from age to age, the sea gets salter and salter; and we guess the age of the sea by noticing how much salt the rivers carry into it every day.

WHY A SOAP-BUBBLE RISES AND FALLS

It is quite true that if a soap-bubble lasts long enough, and does not burst too soon, it will begin to come down again after a little. The simplest explanation of this would be to remember the case of a balloon filled with hot air. It goes up, for a time, and then it comes down again. It goes up because the hot air inside it is lighter than the air around it, and, being lighter, must rise, just as hydrogen would have to rise. When it cools, then the weight of the covering of the balloon brings it down again. Now, a soap-bubble is really a little hot-air balloon, for the air that fills it is warm air from our lungs, and the air is so much lighter than the air outside that it goes up with force enough to carry the weight of the water that makes the skin of the soap-bubble. But this cannot last long, for water is a very good conductor of heat, and the skin of a soap-bubble is very thin, and so the heat from our breath that is inside the soap-bubble soon escapes, and the bubble becomes as cool as the air around it. Then there is nothing to hold up the water of the bubble, and it begins to come down. It is interesting to know that the early experiments for ballooning were actually made with soap-bubbles.

HOW A SOAP-BUBBLE HOLDS TOGETHER

The soap-bubble is really a bubble of water—the soap merely helps; but, as the bubble is made the water is spread out into a sort of skin, and for a time, at any rate, that skin holds together because the particles of which the water is made hold on to each other what men of science call surface tension. Tension simply means stretching, and so the name hints at the forces of stretching and holding, which are shown when the matter that makes up one surface meets another. This question is very difficult.



THE WONDERFUL WAY IN WHICH A SOAP-BUBBLE IS MADE TO HOLD TOGETHER

This picture shows us how a soap-bubble holds together. There are millions of tiny molecules of water, like a wonderful net of beads, blown out into ball shape by the hot air inside. Of course, no microscope could show us a bubble like this, but the picture gives us an idea of how a bubble is made. The molecules of water should really be infinitely smaller and greater in number than they are here, and the lines between the molecules are merely drawn to suggest the way in which cohesion draws the molecules together. There are not really any lines.

and avoid the air on both sides of them. Of course, the bubble cannot last long, for the water which makes it runs down by the force of the earth's attraction until it becomes too thin, and then it bursts.

The point for us to remember just now is that the soap-bubble merely raises a question as to the way in which the surface of a thing behaves when it is next to the surface of something else. It is really a question of

WHY WATER QUENCHES FIRE

Water puts out fire for two good reasons. First, if a thing is covered with water, the oxygen of the air cannot get at it to burn it. But that is not nearly the most important reason why water puts out fire. It is that water has a great capacity for heat, and can hold a great deal of it. It takes so much heat into itself, and so quickly, that it lowers the temperature of the burning thing so that it can no longer burn.

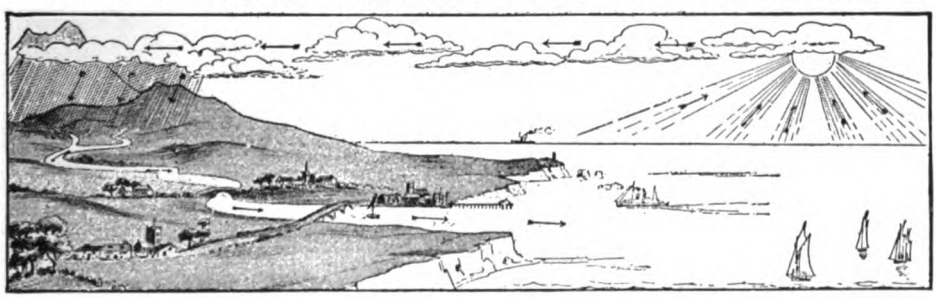
WHY A RIVER RUNS INTO THE SEA

The surface of the earth is not level. It has mountains and hollows, and hills and valleys. Now, everything is always drawn towards the center of the earth, because the earth pulls it, as the earth pulls a ball if you drop it from your hand, or stops the ball and pulls it back again when you throw it up. So all the water in the world is always trying to run to the lowest places to get as near to the middle of the earth as it can. The very lowest of all places are the great basins of the oceans and the seas, and that is why they are full of water. A river runs to the sea for the same reason that drops of water run down a window-pane. All rivers run downhill all the time, even when to our eyes they seem to be running on the level.

But the next thing you will ask is, where does all the water come from, and also why does the sea not get too full? You will find that a wise man in the Bible long ago said: "All the rivers run into the sea, yet the sea is not full; unto the place from whence the rivers come, thither they return again." Now, that is the true answer, though perhaps you cannot understand it at first. The water returns to the places where the rivers came from because the heat of the sun sucks it up into the air from the sea, and the wind carries it over the land, and it makes clouds and falls as rain on the hills and the high places, where it is gathered into little streams and makes the rivers again, doing useful work all the time as it flows. That is why the sea is not too full and does not rise and wash away the land even though all the rivers in the world are always running down into it. Did you ever think that a river might be tired of running down such a long way to the sea? A poet thought so once, and said:

"Even the weariest river
Winds somewhere safe to sea"

HOW THE RAIN RISES FROM THE SEA, AND HOW THE RIVERS CARRY IT BACK TO SEA



The sun draws up the water from the sea as moisture, which mixes with the clouds and is carried overland by the wind, as the arrows in this picture show. When the air cools the moisture becomes water again and falls as rain. The rain on the hills runs down into the valleys and along the rivers back to the sea, because all water, like everything that can run, tries to find the lowest place on the earth, which is the bed of the sea.

WHAT MAKES THE WATER BOIL

To understand this you must know what it is that forms the bubbles when water boils. If you hold a cold plate over boiling water you will find drops of water form upon it, though you can see no water passing upwards between the surface of the boiling water and the plate.

The truth is that, though we always think of water as something liquid and wet, just as we think of air as something that is always a gas, we have no right to do so. Air and water, and everything else, can exist in three different forms, either solid, or liquid, or in the form of a gas. Air, for instance,

is usually a gas, but it is not very difficult to make air liquid, so that it looks just like water, or to make it solid, so that it looks just like ice. Water happens to be usually fluid, but we all know that when it is cold it becomes solid, ice being simply solid water; and we must now learn that, when it is hot enough, water becomes a gas just like air. Indeed, the air contains a quantity of water-gas, or water-vapor, as it is usually called, and when we find the weather close and "muggy," as we say, it is usually because there is more of this water-vapor in the air than we like.

When water boils, then, the bubbles are bubbles of water-gas or water-vapor, and if this vapor strikes a cold surface like a cold plate, it becomes liquid or wet again.

One of the things that decides whether anything shall be solid or liquid, or a gas, is heat; and so, of course, the simple answer to the question, "What makes the water boil?" is heat. We apply heat to water, and it begins to turn into gas, which makes the bubbles.

WHY WATER BOILS AWAY

If we go on boiling the water, of course we boil it all away as gas, until there is none left. In an ordinary way water always begins to boil when it is at a certain temperature, and this is called the boiling-point of water. It is not possible in an ordinary way to have water any hotter than this point, no matter how much heat you apply to it. The result will be not to make it any hotter, but simply to turn it into gas until it is all gone.

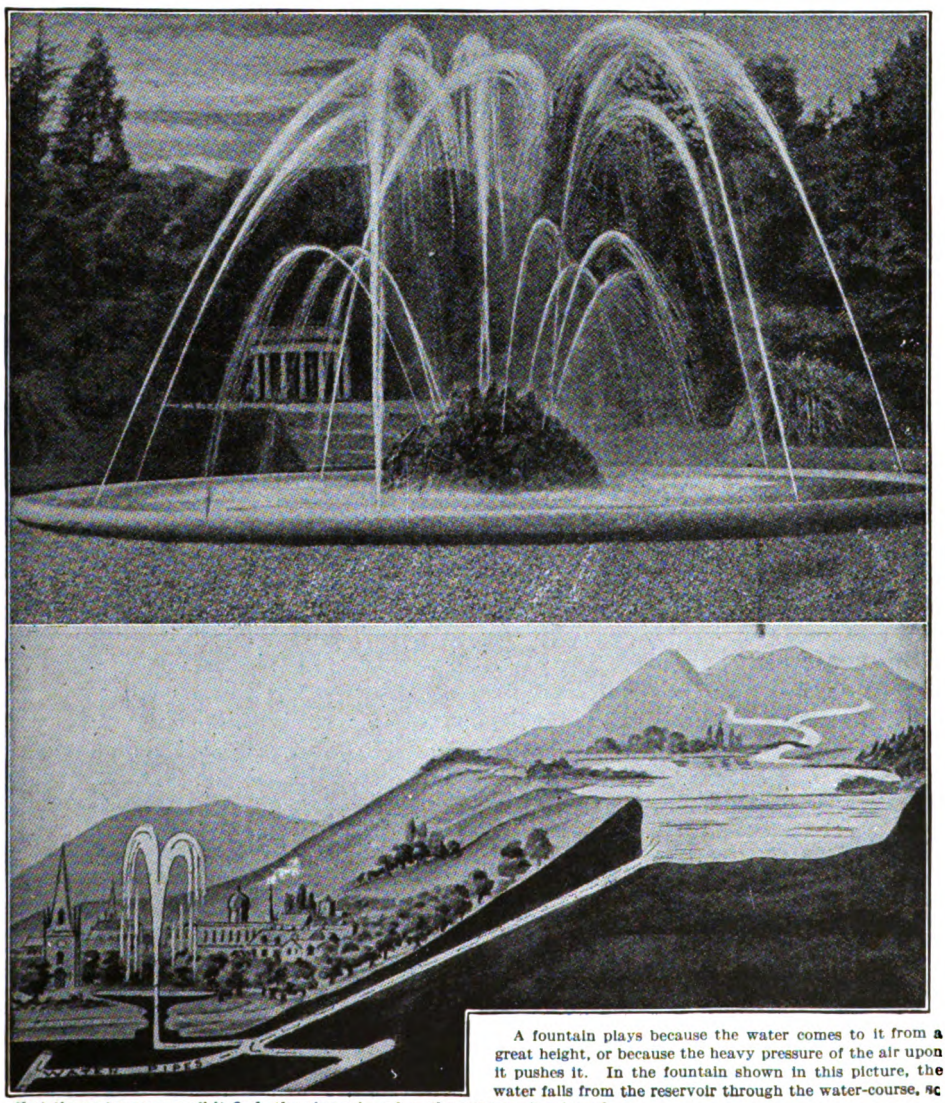
One of the things that decides the boiling-point is the pressure of the air, at the bottom of which we live. Now, if you take some water up to the top of a high mountain, the pressure of air is much less, because there is not so much air above you. If now you heat the water, it begins to boil when it is nothing like so hot as it needs to be made before it will boil at the bottom of the mountain; because on the mountain there is less pressure of air squeezing the water, and so it can more easily expand into bubbles of gas. So if you put an egg in the water at the top of a mountain, you may boil and boil as long as you please, but you will never boil the egg hard, simply because, however long you boil, you can never make the water hot enough to make the egg hard. The water simply floats away as gas long before you can do so! You might almost drink boiling water if you were on a very high mountain.

WHY AIR IS FRESHER AFTER RAIN

There are several reasons for this. For one thing, the rain washes the air, as water will wash anything else. If the air has contained a number of smoke particles, as it does in large cities, the rain has reduced their numbers by carrying them down with it as it fell through the air. Thus the rain helps to rid the air of the sulphurous and other gases which are given off by these smoke particles. Then again, it now seems that the falling of rain often, or always, depends in part on electrical charges in the air, and these charges may help to produce small quantities of the gas called ozone, a variety of oxygen, which has a fresh smell of its own. Then rain cleans the roads and washes away all sorts of things which give off unpleasant odors. We do not realize the extent to which rain is a cleanser in cities; and we must remember that our noses are usually only a few feet above the surface of the street, so that they are exposed to whatever arises from them. A few hundred feet higher, the air would smell very different.

WHY THE FOUNTAIN PLAYS

The puzzling thing about the fountain is that the water comes upwards, though we know that water always tries to fall; it falls because the earth pulls it. Now, something must be pushing the water up more than the earth is pulling it down, and the question is what? The answer is that the water in the fountain is being pressed upon at the end which we cannot see by the air, which is really very heavy; and the fountain is so made that the air pushes one end of the water and makes the other end spout up. If this sounds puzzling, you have only to look at a syphon of soda-water, which is a fountain. If the spout turned upwards instead of downwards, it would be just the same



A fountain plays because the water comes to it from a great height, or because the heavy pressure of the air upon it pushes it. In the fountain shown in this picture, the water falls from the reservoir through the water-course, so that the water runs until it finds the air again, when the pressure is released.

as any other fountain. The air, or gas, inside the syphon presses hard on the soda-water below it, and directly it gets a chance the soda-water rushes up the tube in the middle of the bottle and out at the spout. When you make the soda-water run, you do just the same as the gardener when he makes the fountain play.

WHY RAINDROPS ARE ROUND

First, why does the rain form drops at all? We know now that there is always something which we may call a particle of solid stuff in the inside of a raindrop, and when the drop was made it was made by the water-gas or water-vapor in the air turning liquid upon this solid speck, as steam from boiling water turns liquid on a cold plate held above it.

But you want to know not merely why the raindrop forms at all, but also why, when it is formed, it is so nearly round. The answer is the same as the answer to the question why water forms in round drops on a plate, and the question why it runs in drops down the window-pane when it rains. When water turns liquid it really consists of tiny parts, each of which is itself a part, or particle, as we say, of water, just as a human crowd is made of men and women.

HOW A BALLOON KEEPS UP

This question is really the same in its explanation as the question why does a stick float. If there were no air, the balloon would drop like a stone, just as if the water all disappeared from the sea, the fishes would drop to the bottom. Things float in the sea, or on the surface of it, because the amount of stuff in the space they occupy is less than the amount of stuff in the same space of water. The less dense thing always tends to lie above the more dense, and if the things in question are gases or liquids, they always will follow this rule. If you pour hot and cold water into a bath or into a tumbler, the hot water will lie at the top and the cold at the bottom, because water is less dense, and therefore less heavy, when it is hot than when it is cold. Gases behave in exactly the same way. Hot air behaves in the midst of cold air just as hot water behaves with cold water —it goes upwards.

Now, if you put the hot air into something very light, the hot air, as it goes upwards, will take that something with it. The first balloons were made in this way. Two Frenchmen, brothers, made balloons of silk and linen and filled them with hot air and smoke, and after making balloons which carried animals, they persuaded some men to be carried in this way. You understand that this was simply because hot air is less dense than cold air, and therefore lighter.

WHAT MAKES THE BALLOON GO

But, of course, hot air gets cold, and then your balloon will come down. So we ought to fill our balloon, if possible, with some gas or other which, even when it gets as cold as the air around it, is still lighter than the air. Nowadays balloons are filled with such a gas. Its name is hydrogen, and it is extremely light; indeed, it is quite the lightest thing we know. Oxygen, for instance, is sixteen times as heavy, and nitrogen fourteen times as heavy, and as the air is a mixture of these, hydrogen, if let loose in the air, will fly upwards at once, and, if you have enough of it, it will carry not only a covering to keep it together, but also many people in a car hung from the covering. The interesting thing for us now is simply that it is so very light and therefore is more useful than anything else for filling balloons.

WHAT MAKES A KITE FLY

The case of the kite proves to us that the air has a great power of

holding things up, since the kite has no wings, and yet it does not fall. The air supports it. If you took all the material of which a kite is made and rolled it into a tight ball, it would drop like a stone.

So it is not that the kite is made of something lighter than the air. A balloon flies, we know, because it is filled with something lighter than air but the kite has no light gas inside it, and yet it does not fall. The reason is that it is spread out as wide as can possibly be, so that it may have a large surface for the air to support it. But, of course, if there were no air at all the kite would drop at once, just as the bird would, whether it were flying or not. Neither the kite nor the bird could rise or swim in nothing. Now, the Latin word meaning empty is vacuus, and a place that is quite empty, even of air, is called a vacuum.

What clouds are made of

One of the reasons why we know that there is no water, or scarcely any water, on the moon is that we never see the slightest hint of a cloud when we look at it. If there were people on the moon looking at the earth, they would constantly be finding that the face of the earth was hidden from them by clouds. One of the things which we are studying now in the wonderful planet Mars is as to whether there are any clouds to be seen there, because, if there were, that would help to show that there is water on Mars. Hence, clouds are made of water; or, rather, a cloud is made of many drops of water, which, when they fall, we call drops of rain. Men who study these things are now beginning to learn how it is that sometimes these drops stay in the cloud, and sometimes they fall and make rain. The water has come from the seas and great lakes, and has been drawn up by the sun.

Why coal burns and stone does not

The simple answer to this is that stone is burned already and cannot be burned twice; but that answer wants explaining. What happens when a thing burns is that it combines with the oxygen of the air. When it has taken up all the oxygen that it possibly can and has combined with it, then it is completely burned, and can burn no more.

We watch a candle, let us say, burning, and we are deceived because we do not see the result of the burning. The result in the case of the candle is a number of gases which we do not notice, real though they be; but when various other things are burned the result is not a gas at all, but sometimes a liquid and sometimes a solid.

When the hydrogen gas is burned or combined with oxygen, it forms water. When the element silicon is burned or combined with oxygen, it makes a solid, and most rocks and sand are made of this. An ordinary stone or sand is really silicon which is already burned. But coal is made mainly of carbon which is not yet burned. Burned carbon—that is to say, carbon combined with oxygen—makes the gas called carbonic acid, and that gas cannot be burned any more than a stone can, and for the same reason. Both are burned already.

Why asbestos does not burn

Asbestos is already burned, like stone or sand, and can be burned no more. It is also very difficult to melt, and will not melt with the heat of an ordinary flame; and so it can be used for many purposes—to line safes, for gas-stoves, and so on. The very word is simply taken from the Greek, and means "unburnable." Of course, both in this case and in the case of stone and sand, we cannot doubt that long ages ago all these things were made by being burned or combined

with oxygen when the earth was a very different place from what it is now.

WHAT SMOKE IS MADE OF

Smoke is the result of imperfect burning. Most of the things from which we get so much smoke—like coal—if they were properly burned, would form nothing but gases, which we could not see, and which would very soon fly away and do no harm to anybody. But in order to burn coal properly some trouble and care are required. When we burn coal in an ordinary fire, we do not supply enough air to it. We put the fresh coal on at the top instead of at the bottom, as we should, and so we only partly burn the coal, and small specks of it, unburned, are carried up in the draft, and make smoke. The chief stuff in smoke is simply coal, in specks of various sizes. But the trouble is that a great deal of oily stuff comes out of the coal, and covers the specks of it in smoke, so that these stick to things.

At present the smoke makes black fogs in many cities, and cuts off a great quantity of the daylight by which we live, besides making everything dirty, destroying plants and trees, and filling our lungs with dirt which we never get rid of. There are few things about which we are more careless than smoke, and, besides, we waste a great deal of our fuel.

WHY FLAMES NEVER GO DOWN, BUT UP

We might think, if we had not noticed, that this question was not true, and that flames only go upwards because a gas-jet, for instance, is always directed upwards. But the question is quite true, even in the case of a gas-jet that is directed downwards, for we find that then the flame turns upwards. If we must have a flame going downwards or sideways, then we must have a draft to blow it, just as the wind will blow the flame of a match in any direction.

But even where there is no draft at all in any direction, and when we burn something without sending any gas in any particular direction through a hole, flames always go up, and never down, as the question says. And the reasons are: First, that the gases made in the flame are very hot, and, as hot gases are always much lighter than the cold gases that make up the air around them, the hot gases of the flame tend to rise; and, secondly, every flame, as the hot gases go upwards because they are so light, makes a draft for itself. As the hot gases go up, the space they leave is filled from below, and this goes steadily on, and so makes a draft.

WHY HOT GASES RISE

A gas-jet, properly used, may actually help to ventilate a room by making a draft; and every fire does the same thing, by increasing the natural draft going up the chimney. The gases which are produced when anything burns are themselves burned, once and for all; they can neither be burned again, nor can they help to burn anything else.

These gases consist chiefly of carbonic acid gas and water-vapor. They are both of them completely oxidized—the carbon of the one and the hydrogen of the other are combined with all the oxygen they can hold. Nor will either of them give up its oxygen for the burning of anything else. Thus, if hot gases did not rise, and so make room for fresh air—which really means fresh oxygen—nothing could burn for long; for nothing can burn in an atmosphere of carbonic acid and water-vapor, and such an atmosphere would at once surround every burning thing if hot gases did not rise.

WHY THE SEA LOOKS SOMETIMES BLUE AND SOMETIMES GREEN

On a black night, when there is no light for the sea to reflect, the sea looks

black. When the sky is gray, the sea reflects the light that falls upon it, and looks gray. The color we usually think of as the color of the sea is blue, because the sky is blue, or ought to be; and if it be blue light that falls upon it, it is blue light that the sea reflects.

Yet sometimes the sea is green, though the sky is never green. Parts of the sea are shallow, especially near the shore, and may be so shallow that some of the light from the sky may pierce the water, reach the bottom, and be reflected from it to our eyes. So, of course, the light will be changed, partly according to the color of the bottom of the sea, and partly because of the greenish tinge of sea-water itself. Besides all this, we have to remember that the same part of the sea on a coast we know well may be of a different color on different days, even though the water is the same and the color of the bottom is the same, because the sun is in a different part of the sky, and so the light strikes the bottom differently, or because the sky is clouded, and so the light which reaches the sea from the sky is different. Thus, there are many different things which will affect the color of the sea, and that is why its color changes so often and is so beautiful to see.

WHAT CHANGES THE COURSE OF THE WIND

Like almost everything else, the air is always moving, more or less, and the changes in the direction of its movements are due to many different things. There is, for instance, the movement of the earth on itself, and also its changing position in regard to the sun as it goes round the sun. These movements mean that different parts of the earth are exposed to the sun at different times; and that means, of course, that different parts of the air are exposed to the sun at different times. When the sun shines on the air it makes it warm, and warm air is lighter than cold air, and will rise, while cold air will flow in to take its place.

But there is a great deal more in it than this. Besides the fact that the surface of the earth is not smooth, but has mountains and hills that turn the wind as the earth turns, and tracts of water which cool hot air as it passes over them, there are all sorts of electrical changes always going on in the air, and these probably affect its weight—perhaps even the proportions of the various gases in it—even as much as the heat of the sun affects it. You can scarcely ask more difficult questions than these about wind, rain, and weather.

WHY FLOWERS SMELL SWEETER AFTER RAIN

Where there is any vegetation rain has a great influence in making the air smell fresher, for water has a special power upon the activity of many kinds of vegetable life that produce pleasant scents. We say that the rain brings out the fragrance of the flowers, and that is true. All life requires water, and all the processes of living creatures are helped by a good supply of water. When rain falls on flowers, and on many kinds of leaves, it sets going the chemical changes which result in the production of many pleasant odors which are added to the air, and so help to make it smell "fresh."

COULD WE LIVE WITHOUT RAIN?

The good of rain is that it soaks into the soil and is sucked up by the roots of plants, which must have it if they are to live. If there were no rain there would be life only in the sea. In parts of the world where there is no rain there is little life. In this country we have no idea, just because we are so well off, how rain is loved and treasured and prayed for in other countries where there is not enough of it, or

where it falls only at certain seasons of the year. We must think of rain then as something that cleanses the air, nourishes the vegetable life upon which our own life depends, and insures a supply of fresh water all the year round in every part of the world where sufficient rail falls.

WHY THE BEDS OF RIVERS CHANGE

The earth's crust is shrinking all the time, as the interior cools and shrinks beneath it. This means that the land changes from age to age, and one consequence of this is that often the water of a river finds that its steepest and quickest course to the sea is different from what it used to be, and so the river-bed changes; the old one is deserted by the waters, and a new one is formed.

But the water itself, as it flows, rubs and melts away the earth it flows over, and so grinds a deeper and ever deeper bed for itself. Thus it gets less and less likely to desert its old bed the longer it flows there.

WHY IT IS EASIER TO SWIM IN SALT WATER THAN IN FRESH

Swimming really has two parts—one is to keep up in the water, and the other is to move along in it. The question is: Why is it easier to keep up, or to float, in salt water than in fresh? The answer depends wholly on the heaviness of our bodies as compared with the heaviness of the water. Our bodies are more than three-fourths water, but most of the rest is heavier than water. The fat of our bodies is lighter than water, and so helps us to float.

Now, fresh water is less heavy than salt water, and so our bodies, though only a little heavier, tend to sink in it. Ordinary sea water is heavier than fresh water, because it contains a lot of salts, just as the water of our own bodies does; so we find it easier to float and swim in sea water. But in some parts of the world there is water that is much salter than even sea water; this is the case, for instance, in the Dead Sea, and the Great Salt Lake in Utah. There is so much salt in the water of the Dead Sea that it is actually heavier, on the whole, than our bodies are, so you cannot sink in the Dead Sea! On the other hand, there are some liquids much lighter than water, and if a man were to fall into a lake of one of them he could not swim at all, however good a swimmer he might be; his body would sink like a stone in such a light liquid.

WONDERS OF EARTH, SUN AND STARS

WHY AN APPLE FALLS

NO one in the world knows why an apple falls to the ground. We simply know that the earth and the apple pull each other together—the apple, being small, moving a long way, and the earth, being large, moving a very little way—no one knows why they pull each other. But everything in the wide world pulls everything else in this way, as was proved by Sir Isaac Newton. It may be that as a boy while lying under an apple tree in his father's garden, saw an apple fall, and thought. "The earth pulls the moon and keeps it running round her, just as it pulls the apple," he said. If the moon stopped moving round, it would rush to the earth as the apple does. So he discovered the law of universal gravitation.

Now, the more stuff there is in a thing the more strongly it is pulled by everything else. So the earth should pull a big weight more strongly than it pulls a small one, and it does. Then the big weight will fall quicker than the small one, men thought.

They forgot that it takes a stronger pull to pull a heavier weight; the heavier it is, the stronger the pull, but the more the pull has to do. Therefore, a heavy weight and a small one fall at the same rate.

HOW THE LEANING TOWER OF PISA STANDS

In the town of Pisa, in Italy, is a famous leaning tower, which has stood for hundreds of years.

There is nothing in the whole world quite like the leaning tower of Pisa. Its building was begun more than 800 years ago, since the people who lived in Pisa wanted to have a tower as fine as the great bell tower of Venice. Yet, though the tower of Pisa met with a strange accident that might have ruined it, it still stands, and the tower at Venice fell down a few years ago! We know now that the tower was not meant to lean, though it is 13 feet out of the straight line!

The tower was built on wooden piles, driven into ground so soft that when the tower was little more than begun it began to sink on one side. There is no other tower in the world that leans so much as this at Pisa. The tower does not fall because, as they went on building it, they made it in such a way that if you dropped a straight line down from a certain point in the tower, called the center of gravity, which is equally balanced on all sides, by the weight of the tower, that line would touch the ground within the foundations of the tower. If the line reached the ground somewhere outside the tower, it would fall.

But the tower is very interesting for another reason, and the reason is that its peculiarity was used by one of the greatest men who ever lived, in order to make one of the most famous experiments. This man was the great Italian astronomer Galileo, who, more than 300 years ago, was a professor in Pisa, and was thinking for himself. The great Greek thinker Aristotle, nearly 2000 years before the time of Galileo, had declared that if you took two balls of the same material, one small and the other large, and dropped them at the same moment, the large one would reach the ground first. If it was ten times as heavy as the small one, he said, it would fall ten times as quickly.

Nowadays, when anyone says anything like this, we always make the experiment at once, and let Nature decide. But in the old days very few men thought about this; they chose some great man, and made him their authority. So for nearly 2000 years everyone believed and taught what Aristotle had said about falling weights, and no one made the experiment to find out the truth.

At last, however, came Galileo, and he was thinking for himself. He said that the two weights would fall in just the same time, even though one was heavy and the other light, and everybody laughed at him. It is always a hopeful sign when everyone laughs at you—at least, no one has ever done anything in the world who has not been laughed at. "Very well," said Galileo, "come and watch me make the experiment." So one morning, before the assembled university, professors and students, he ascended the leaning tower, taking with him a ten-pound shot and a one-pound shot. He let them go together. Together they fell and struck the ground.

And so, you think, everyone praised Galileo for having found out a new truth, and he was famous ever afterwards. But one of the lessons we have to learn is that that is not what men usually do in cases like this. What really happened was that everybody abused the young man for daring to differ from Aristotle.

They started hissing at Galileo's lectures, and in a very short time he had to leave Pisa—turned out for finding a truth. The same thing happened to many great men before Galileo, and has happened to many since.

WHERE THE STARS STAY IN DAYTIME

The stars in the daytime are just where they are at night, and if something could be put over the sun we should see them again. Something is put over the sun sometimes, for the moon comes in the way, so that for a time it cannot be seen, even though it is daytime and there are no clouds in the sky. When that happens, one of the most wonderful things in the world is to see the stars "come out again." They were there all the time, shining as brightly as ever, but the sun is so very much brighter to us—because it is very much nearer—that we could not see them.

When you are listening to thunder, or to a cannon, you do not hear the quiet sound of your own breathing, although the thunder is far away and the breathing is near; and just as the great noise swallows up the little sound, so the great light of the sun swallows up the little light of the stars. There is another way of cutting out the light of the sun so that the stars may be seen in the daytime. Men who work at the bottom of a pit or a well, and look up at the little bit of sky above them, see the stars almost as brightly in the day as in the night.

WHAT KEEPS THE SUN BRIGHT

You would think that the sun is bright because it is burning—that it is an enormous fire. But when a thing burns, the stuff of which it is made joins with the oxygen of the air in which it burns. The sun, however, is actually so hot that nothing can join with anything else in it; nothing could burn in the sun. There are plenty of things which would burn there, and plenty of oxygen to burn them with, but they are kept apart by the heat. Also, even if things could burn in the sun, that would not keep it alight, but it would have burned out ages ago, and we should not be here.

Last century we found out to what agency the sun owes its heat and light. They come mainly because the sun is shrinking. It shrinks, or contracts, by gravitation — the power which makes every piece of stuff in the world attract all other stuff to itself. The sun has been shrinking for many ages, just as the earth has been shrinking. Indeed, long before the earth was formed, the sun was stretched out as far as the earth's present distance, and even as far as the earth's farthest brother, the planet Neptune. As the sun shrinks its parts strike each other, and their motion is stopped, and heat and light are produced, just as when one piece of flint is struck by another.

So it is gravitation that really gives us the heat and light which keep us alive. Astronomers have also come to attribute the presence of radium as a cause of heat. Probably the sun is also kept warm, as the earth, we know, is kept warm, by having in it some of the wonderful element radium, which produces heat from within itself.

HOW BIG THE WORLD IS

The world is nearly round. From the North Pole to the South Pole, straight through the earth, the distance is about 7899 miles. A pole thrust through the center of the earth, from side to side, would measure about 7925 miles. The distance right round the outside is about 24,850 miles.

The round world is a vast mass of land and water, surrounded by air. It spins like a top, it travels round the sun, and it moves forward with all the stars in the heavens—forward and forward. forever and ever. So tre

mendous is the size of this huge globe, that the mighty range of mountains which we call the Alps are only likely the burrowings of a mole on the ground.

Now, if the Alps are so small in comparison with the size of the earth, how much smaller must man appear?

HOW MAN CONQUERED THE EARTH

Man conquered the earth, on which he is like an atom, because he is not content to stand still like the Alps. Though he is so much smaller than these mountains, he has a brain which enables him to triumph over the weakness of his body and the smallness of his size. He can move; he can think; he can manufacture.

You can imagine how, in the far past, our savage ancestors would watch birds sailing through the air over the deep waters, and long with all their souls to have that power of flight. For one of man's chief qualities is curiosity. Man is always wanting to find out things. And naturally the first thing he most wanted to find out was the kind of earth on which he lived. So our early ancestors looked across the waters, and dreamed of lands on the other side of the globe.

The curiosity of men is the beginning of geography, for curiosity led men to look about them and observe the earth. When they had learned to build ships, they sailed across the seas, visited many foreign lands, and returned with descriptions of those places and the people they had lived among. These descriptions we call geography.

DO PEOPLE LIVE ON THE MOON?

We have seen only one side of the moon, because, as it goes round the earth, it turns slowly on itself, so as always to keep the same side turned towards us. But we are quite sure that there are no people on the moon, either on this side of it or on the other side, which we have never seen. People could not live on the moon because the moon has no air and no water. Even if people could live there without air or water, they would probably be burned to death in the daytime, having no air to protect them from the heat of the sun, and they would be frozen to death at night, having no air to keep in the sun's heat.

But possibly at one time there may have been humble forms of plant life on the moon, and some people suppose that there may be a little of this even now, for it is possible that there may be a tiny amount of air and water still left at the bottom of some of the deepest valleys in the moon. If there were a building on the moon as big as the Capitol at Washington, we should easily be able to see it through our biggest telescope, but there is not the slightest indication that intelligent beings have ever made a mark of any kind on the moon.

WHAT THE STARS ARE MADE OF

Not very long ago, a great thinker declared that this great question was one which men would never be able to answer, however long they thought and however hard they worked. Our telescopes could never tell us; the biggest telescope that could ever be made would never tell us.

It would only make the star look nearer and brighter, but would tell us no more what the star is made of than our eyes can tell us without a telescope. But now we have a wonderful instrument called the spectroscope by which we can study the kind of light that is given out by any star that we can see. And since we find that the light of the stars, thus studied, is exactly the same as the light given out by things we know on the earth when they are made hot, we now know that those

same things are found in the stars.

So, the answer is that the same kind of stuff of which this paper, and your eyes, and our ink and pen are made are to be found in the stars. The stars are made of the very same kinds of stuff as the earth is made of. Of course, all the stars are not the same. Even with our own eyes we can see that some are redder and some whiter than others. Some have more oxygen in them, and some less, but the point is that it is oxygen, the same element as we breathe at this moment.

WHY THE STARS TWINKLE

This sounds a very much easier question than the last, but we are not yet quite certain of the answer. Of course, you know that it is stars that twinkle, and not the other wonderful things looking like stars, which are called planets, and which, like the earth, belong to the sun's family.

The planets shine by the light of the sun, which they throw back, or reflect, from themselves, as the moon does, and, like the moon, they shine steadily. But the light of the stars is made by themselves, and comes over immense distances to us, so long that the light by which we see the nearest star left it about four years ago.

It is likely that this light interferes with itself as it comes, so that it seems to come in little beats, and people who have studied this think that it is much the same as what sometimes happens with the piano or an organ when the sound seems to get louder, and then less loud, backwards and forewards. In the study of sound this is called a "beat," and it is probable that the twinkling of the stars is really the same kind of thing. It may be that the air has something to do with disturbing the light, and that perhaps starlight is more affected by the air than the sunlight by which we see the moon and the planets.

HOW A STONE IS MADE

Stones are really pieces of broken rock. By the side of the road you can see stones being made with a hammer. These are sharp, as they have been rudely broken.

But rocks are broken up in many other ways. Even the life in the soil on a cliff, for instance, may gradually break up the surface of the rock. If the pieces rub against each other, and are open to the wind and the rain, then they get rounded and dull; but if you take many of these stones and break them, you will find the unchanged rock inside them, often beautifully smooth and bright. There are other kinds of stones which are quite soft. Those we have been speaking of are made of real rock which long ages ago was made under the action of great heat. But you may pick up sometimes a soft stone which you can quite easily rub away—a piece of soft sandstone, which is really very much the same as the sand on the seashore.

IS THE MATTER IN EARTH AND AIR ALWAYS CHANGING PLACES?

There is a ceaseless circulation going on between the surface of the land and the water, and the bottom layers of the ocean of air which covers them both. Wherever water is, for instance, it is often being sucked up in the form of a gas into the air, of which it then forms part; while, on the other hand, water vapor from the air often passes from it to the earth—as, for instance, in the form of dew. Then the gases of the air, especially oxygen and carbonic acid, are ceaselessly passing between it and the bodies of all the living creatures on the earth; then, from moment to moment, various gases are either leaving the air to be dissolved in the ocean, or are leaving the ocean to join the air.

If we could, it would be well for us if we could mark an atom of oxygen,

and watch it for a year or two; and see all the amazing things it does: passing in and out of the bodies of living creatures, in and out of the earth, in and out of the ocean. Then, if we remembered that all the other atoms of oxygen and of other things, too, were doing the same kind of thing, we should begin to understand how wonderfully alive, the whole world is. Perhaps the whole world, indeed, is really alive!

WHAT KEEPS THE STARS IN THEIR PLACES

The stars are not kept in position, but are all in movement, and sometimes the stars do fall on to one another, we now believe. Astronomers now think that they can find in the heavens two great streams, to one or other of which all the stars belong; and these two streams of stars are moving through and past each other in opposite directions.

No one has any idea at all how this process started, nor what the results of it will be, but at any rate we are quite certain that there is no such thing as what for so long has been called a fixed star, anywhere. Some people have thought that there may be a center somewhere, which all the stars move round, but we cannot find any proof that this is really so.

WHY EVERY CLOUD HAS A SILVER LINING

The reason is simply that at its edge the cloud is thinner, and much more light can get through it, and that gives it its silver lining. Some clouds, however, are very thin, just like a sheet of tissue-paper in the sky, and we can scarcely notice a silver lining to them. Of course, if we went up in a balloon, above an ordinary cloud which seemed to have a silver lining to us when we were on the earth, we should see the whole cloud bright because the sun would be shining upon it, and it would throw back or reflect the sun's light to our eyes. This is true of the darkest and blackest clouds all through the daytime. The sun is always shining, and the darkest cloud has a bright side.

The trouble for us is that we see the dark side, but we ought to know and remember that the bright side is there. Of course, as we see, all this may have a meaning that applies to the troubles of life, big and little. That is why people remind us that every cloud has a silver lining. But it is even better than that, for every cloud has a silver side just as bright as the other is dark. Some people's minds are always like our eyes in a balloon. They seem to see every cloud on its silver lighted side. These are the kind of people that it is good to live with.

WHY ALL THE WORLDS ARE ROUND

It is true that all the worlds are round, or very nearly so, and that, if they are not quite round, there is a reason. The earth, for instance, is not quite round, but bulges a little at the equator, simply because it revolves so quickly that it gets a little out of shape. There is something special about roundness, for not only are all the worlds round, but a thing like a drop of water tries to make itself as round as it can; and if you drop melted lead from a height you get round shot. The reason is that in all these cases you have some force trying to pull all the parts of the world or of the drop towards each other. That shape is the sphere, or a round ball.

WHAT MAKES THE SHADOWS THAT GO UP AND DOWN HILLS

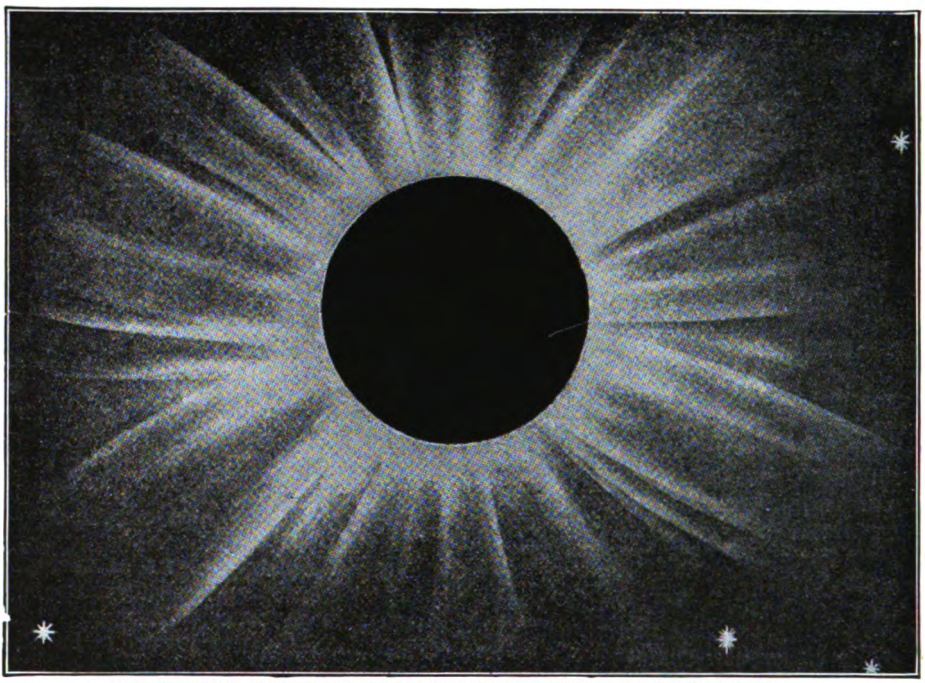
The shadows that we see crossing the face of the hills are the shadows of clouds. They can be seen passing over the sea, too, or running across the field of play when you watch a game of baseball. They are best seen when there are small clouds quickly moving, and with well-marked edges, passing

across the sun, as it seems to us, on a bright day. Sometimes they move more quickly than at other times. This depends partly on the wind, which varies very much in speed, and on the height of the clouds.

THE BIGGEST SHADOW THAT WE CAN SEE

There is one great shadow, thousands of times bigger than any other, which men have noticed at times in all ages, and which has often made them very much afraid. This is the shadow of the earth itself, and it is thrown upon the moon. It sometimes happens that the earth gets in the way of the light from the sun which would fall upon the moon if the earth were not there. And so we get what we call an eclipse of the moon. As we watch the moon, we can see a round shadow beginning to creep across it.

Sometimes it passes over only part of the moon; sometimes it covers the whole moon for a little while, and we call that a total eclipse of the moon. When we watch this shadow—one does not even need a glass to see it with—it is easy to see that the shadow is curved. It is the shadow of a round thing, and this is one of the proofs that the earth is really round. In olden days men used to be very much afraid of eclipses of the moon and of the sun. They used to think that it was a warning of something terrible about to happen. But now we know that an eclipse of the moon is nothing more than just the throwing of a great shadow upon the moon's face, and that is the shadow of the earth, by far the greatest shadow that anyone can ever see.



THE SHADOW OF THE MOON BLOTTING OUT THE FACE OF THE SUN

This is one of the most impressive sights that men have ever seen—the moon passing across the face of the sun. It happens sometimes that the moon gets directly in the way of the sunlight which would fall upon the earth if the moon were not there, and we call this an eclipse, or covering up, of the sun.

WHAT MAKES AN ECLIPSE OF THE SUN

The kind of eclipse that used to frighten people most is an eclipse of the sun. It does not often happen

that the sun is totally eclipsed, but when this does happen on a bright day, the effect is wonderful. It suddenly becomes dark, until it is like night; it turns cold; the dew falls; the birds go to roost; the flowers go to sleep; all this, perhaps, in the middle of the day, and with not a cloud in the sky. Then, just as suddenly the daylight returns. An eclipse of the sun is not due to a shadow, but happens when the moon gets between the earth and the sun, and we see the moon pass across the sun.

This happens quite often, but it is not often that the moon passes across in such a way that, for a little while, it exactly fits over the sun, and cuts off all the light. Those are the startling times. We know beforehand when they are to happen, and to what parts of the world we must go to see them, and exactly how long the period of real darkness will last. Great preparations are made, and men go with telescopes and cameras and all sorts of other instruments, perhaps to Greenland, perhaps to some island in the Pacific Ocean, just for the sake of the forty seconds, or perhaps it may be as much as four minutes, during which the moon will exactly fit over the face of the sun. For we can see things and learn things about the sun during those few seconds as we never can at any other time.

THE MILKY WAY

Students of the stars think that the Milky Way is the boundary of our world of stars. It is a complete closed circle where the sky is crammed with stars; yet in places there are gaps where we can see through beyond into nothing. We can begin to measure the diameter of this great circle. Our own sun and system seem to be somewhere near the center of it, and a very remarkable thing about the sun, and therefore about us, seems to be that it is very much alone in the world of stars. The sun has no near star neighbor, while most of the other stars are much more neighborly, especially throughout the whole circle of the Milky Way. We cannot tell at all whether the whole Milky Way is moving through space, and we do not know whether it is moving round on itself; but we can study and photograph it now, and long years afterwards our successors may compare our photographs with what they then see, and may be able to learn about these things.

Look closely at the Milky Way on a bright night, and you will see that it is made of many stars, only they seem so closely packed together that their light is all blended, looking like a thin cloud or a milky streak spread across the sky. If you use an opera-glass or a telescope, you see the separate stars more clearly, and if you take a photograph through a telescope—which is quite an easy thing to do—you find that the stars of the Milky Way are to be counted not in thousands, or even in hundreds of thousands, but actually by the million.

From any one part of the earth we can see only about half of the Milky Way, but this great streak of stars really forms a mighty circle, the different parts of which can be seen from different parts of the earth. The sun and the earth and other planets with it lie somewhere not very far from the center of this great circle. Now every one of these millions of stars is a sun like ours, only some are smaller than our sun, and many are larger. Any or all of these suns, for all we know, may have one or many planets circling round it, just as the earth moves round the sun. We cannot see these planets, for they must be too small, and without any light of their own, just as the earth is. So that if we

were to allow only two or three planets to every star or sun that makes up the Milky Way, that would mean hundreds of millions of worlds of varying sizes.

WHAT THE STREAKS OF LIGHT ARE THAT SOMETIMES SHOOT ACROSS THE SKY

These are called shooting stars. Of course, they are not stars, but quite small things, often just like stones, though some of them are made of iron. They look bright merely because, as they rush through the air, they get very hot. The smaller ones, no doubt, get so hot that as they pass through the air they burn all away, just as a candle does, and so they never reach the earth at all. But larger ones actually reach the earth, sometimes making big holes where they fall. You may have seen such things in museums, and you can look upon few things more interesting if you think of their history, for in the beginning these things did not belong to the earth at all; only they were rushing through space, many parts of which contain large numbers of things like pebbles, and they were caught by the air of the earth and the earth's gravitation.

Many of these meteorites, as they are called, are believed to have once been part of the bright things called comets. Sometimes an accident seems to happen to a comet and breaks it up, and in the path where this comet used to travel round the sun there is, instead, a great shoal of meteorites. When the earth, in her path, happens to cross the path of the meteorites, many of them will be caught, especially if it be just at the time when the thickest part of the shoal is passing. So we know the times of the year and the special years when we may expect to see a large number of streaks of light in the sky at night. The best showers of shooting stars are usually seen in November, when the earth crosses the path of a shoal of meteorites called the Leonids.

IS THE EARTH HOLLOW INSIDE?

Though no one has ever seen, or ever can see, the inside of the earth, we are certain that the answer to this question is "No." We know that the earth has a solid crust, very thin, and very apt to crack and "buckle," producing such things as mountain chains in consequence, and we can prove that this crust must be utterly different from what lies underneath it. Now one of the many ways in which we can learn about the inside of the earth is by weighing the earth, and noting its weight in comparison with its size. This teaches us what the density or denseness is of the stuff that makes the earth, and the result is a conclusive answer to the question.

If you have a small ball which weighs tremendously heavy — f a r heavier in proportion to its size than any ball you play with—you would not suspect it of being hollow, but rather you would wonder how it came to be so tightly packed and squeezed together. That is the case with the ball we call the earth. Its denseness is very high, indeed, and the material in it is packed together with more tightness than we can imagine. We have just scratched the surface of the earth, and already in going down even such a short distance we find the density increasing, as it must, if we think of the weight that lies over us at the bottom of a mine.

WHAT CAUSES AN EARTHQUAKE

The first reason that probably accounts for all earthquakes is simply that the earth is shrinking as it gradually loses the heat from its surface. We know that the earth has a thin crust, which is comparatively cool, and hot inside. The crust rests upon the inside of the earth, and as the

inside shrinks it is bound to leave parts of the crust unsupported, so that they are apt to sink or crack. This will happen especially where the crust of the earth is thinner and more liable to crack than in other places. It is very common in Japan, for instance, and very rare in the Mississippi Valley.

But when an earthquake happens at any part of the earth, it starts a wave of disturbance that travels right over the earth, and can be detected anywhere by means of the seismograph. Then, if we notice the time when the wave reached a place, and find out what the time was when it started, we can learn how quickly the earth-wave travels. But sometimes no one knows where the wave started, and then very often we can guess that it started under the sea; for earthquakes may start in the earth's crust where it forms the beds of great oceans as well as anywhere else. And so there may be earthquakes at the bottom of the sea.

HOW THE PLANETS GOT THEIR NAMES

The names of most of the planets are very old indeed, and they were given to them for interesting reasons worth knowing. Mercury moves very quickly, for it is so near the sun that it would be drawn in unless it moved quickly, and its name—Mercury—is after the "messenger of the gods," whom the Greeks and Romans invented and believed in. Then Venus is very beautiful and gets its name from Venus, the supposed goddess of beauty. Mars is reddish and so suggests blood, and was therefore called Mars, after the god of war. Jupiter is the biggest of the planets, and is called after Jupiter or Jove, the greatest of the gods whom people believed in long ago.

Then, to take one more instance of the way in which the planets are named, there is Uranus, now so named, like the others, after an ancient god. It was discovered by a German, William Herschel, who lived in England, and he wanted to call it Georgium, after the King of England. Others wanted to call it Herschel, after the discoverer, which would certainly have been wiser than to name it after a king who had nothing at all to do with it; but finally it was agreed to give it an old name like the others.

As for Earth, the good mother of us all, the ancients called her Ge, and so now we call the study of the earth ge-ology; while what we call the moon they called Luna. Hence, we have the word lunatic, because in ancient times it was thought that when a man lost his mind, it was through the influence of the moon.

WHO GAVE THE STARS THEIR NAMES

Nowadays we know an enormous number of stars—about 100,000,000—and the smaller ones (or rather the fainter ones, for they may only seem small because they are distant) simply get numbers or letters, for all the world like automobiles, in order to identify them. But the brightest stars have been known for many ages, certainly not less than 10,000 years, and the origin of their names is lost, like the names of the men who named them.

Some of these names we call Latin and Greek and Arabic, but certainly many of them are far older than the Romans or the Greeks or the Arabian astronomers, and they got the names from those who went before them, just as we have got the names from them. A star with a specially interesting name is the Polar star, which gives us the direction of the north. No one can say how many millions and millions of sailors' eyes, throughout thousands of past years, have been gratefully and often anxiously fixed upon that star, by which they could steer their way home across the path-

less sea. But for all those sailors that star has doubtless been known by whatever word stood for north, in whatever language the sailors spoke. The names of great stars like Aldebaran and Sirius must be older than any human record.

WHERE THE DAY BEGINS

The world is full of mysteries and of wonders, and there is no need for us to puzzle ourselves by making any that do not really exist. We could quite easily make all sorts of puzzles about time and the way in which it is reckoned; but we must understand that these puzzles are not real, but are made entirely by ourselves—not by Nature.

The real fact is quite simple. The sun goes on shining all the time, you know—it is well to remember that "the sun is always shining somewhere" —and the earth is spinning all the time. So the sun is always seeming to rise somewhere, because at some place or other the earth is just spinning round, so as to face it, and the sun is always seeming to set somewhere, because at some place or other the earth is just spinning away from the sun. That is simple.

And, of course, whatever we call now, whether we call it six o'clock or twelve o'clock, this now is now everywhere. The present moment is the present moment here and on the farthest star. Only when just opposite the sun we call that midday, whereas the people on the other side of the world are then away from the sun, and call it midnight; but this present moment of ours is their present, too, of course, and the difference is merely a difference of name to indicate that now we are opposite the sun, and they are away from it. It would be foolish for us to make a mystery where none really exists, or to forget that now must be now everywhere.

But, simply because the earth goes on spinning, and the sun is always shining, the day is dawning somewhere always, and really, therefore, the answer to the question, "Where does the day begin?" is that the day is always beginning somewhere.

TWO DAYS AT ONCE

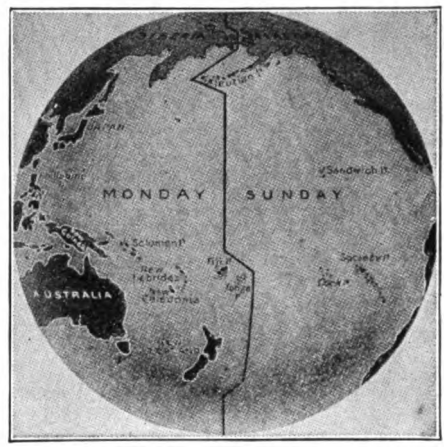
Since people live in different parts of the world, what we call night (when it is our night) will be someone else's day, and our midnight, when a new day begins for us, as we reckon, will not be the midnight of other people in other parts of the world, so that what we call Monday they may call Tuesday, yet we and they are both talking about the same moment!

Now, it would be very inconvenient if all the different parts of the world east or west of each other persisted in talking of time as if they were the only people on the earth, and as if their midnight must be everybody's midnight—which it is not. So we reckon by two sorts of time. One is local time—the time reckoned by what is happening at the particular place whose time it is; the other is standard time, which we agree upon, so that we can catch trains, and so on, just as if midnight in one place were midnight everywhere. Up to 1883 people often missed trains through this difficulty, and then "standard time" was invented.

WHERE THE DAY CHANGES

A clock shows that it is never midnight at the same time at any two places which are not the same distance from the line passing through Greenwich—or, indeed, from any such line, only we take Greenwich for convenience. Therefore it may be one day at one place, and the day before or the day after at another. In order that we shall not get more mixed than we can help—and we cannot help

getting rather mixed since we don't all live on the same line, and the earth will keep on turning!—we have agreed that we shall take a line exactly on the other side of the earth from the Greenwich line, and this we call the "date line." What is called Sunday on one side of this line is Monday on the other side. If the "date line" passed through a country or through a city, this would be inconvenient. People living on opposite sides of the same street might have different days for Sunday. They would have no doubt that now is now everywhere, but they would call now by different names. Fortunately, however, the date line scarcely touches any land at all, and the little it does touch is very unimportant. The line passes across the ocean.



The international date line, with Sunday on one side and Monday on the other

THE CHILDREN'S "WHYS" AND "HOWS"

WHY WE COUNT IN TENS

YOU may well ask why we count in tens, for it would be much more convenient if we counted in twelves—if we had a duodecimal system of counting in twelves instead of a decimal system of counting in tens. If we should invent two extra single figures for ten and eleven, and then write ten to mean twelve, and eleven to mean thirteen, 100 to mean 144 (twelve times twelve instead of ten times ten), and so on.

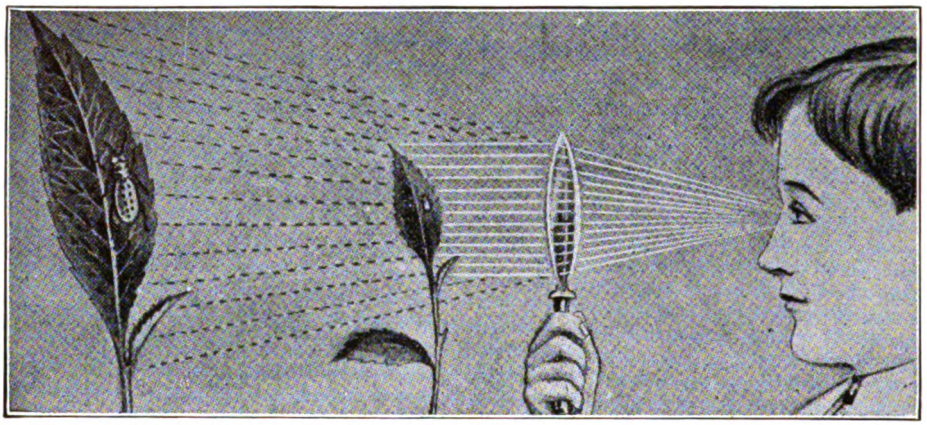
Perhaps we will do this some day; and the reason is that, while ten can be evenly divided only by two figures, two and five, twelve can be evenly divided by four figures. Thus, for many purposes it would be better to count in twelves, and, indeed, we often do so when we can, as, for instance, by making twelve inches to the foot instead of ten. This would also fit in nicely with the number of months in the year. But we count in tens still, as a rule, and we shall doubtless do so for many a long day yet, simply because our ancestors have always done so.

If you think how you sometimes used to reckon when you started arithmetic, you will guess the simple reason why. It is because we have ten fingers. When we count on our fingers, as children do, and as the first men did, it is natural to make a fresh start after ten, because then we go back again to the finger we began with. So all over the world, we find men counting by tens—using a decimal system—just because men and women everywhere have ten fingers.

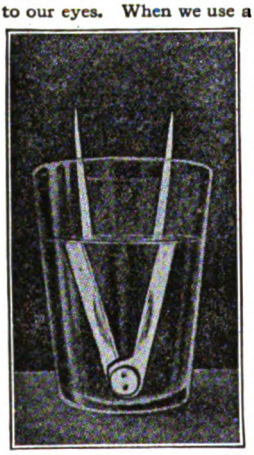
WHY A STONE SINKS

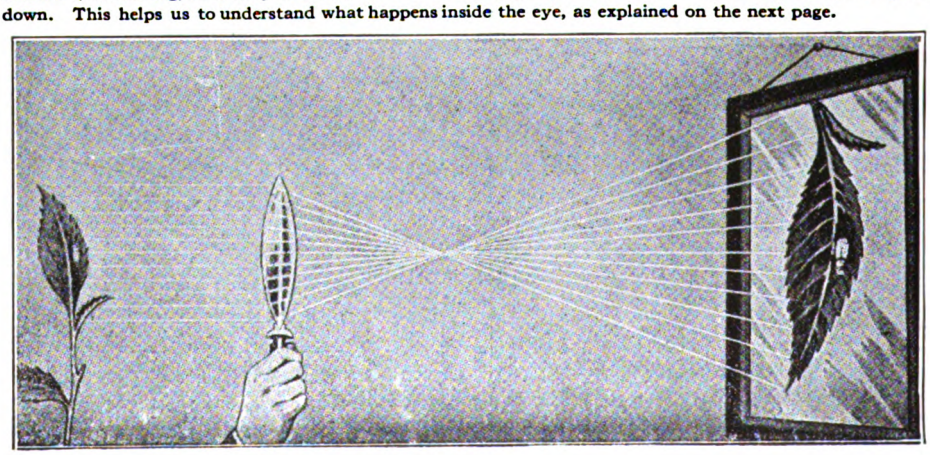
The stone sinks because it is heavier, or denser, than an amount of water occupying the same amount of room; and the water floats on top of the stone just as the stick floats on top of the water. It all depends upon the great law of the pull, or attraction, of the earth for everything outside it, and the heavier the thing is, the stronger the pull. A lump of iron sinks in just the same way.

HOW A MAGNIFYING GLASS MAKES THINGS BIGGER

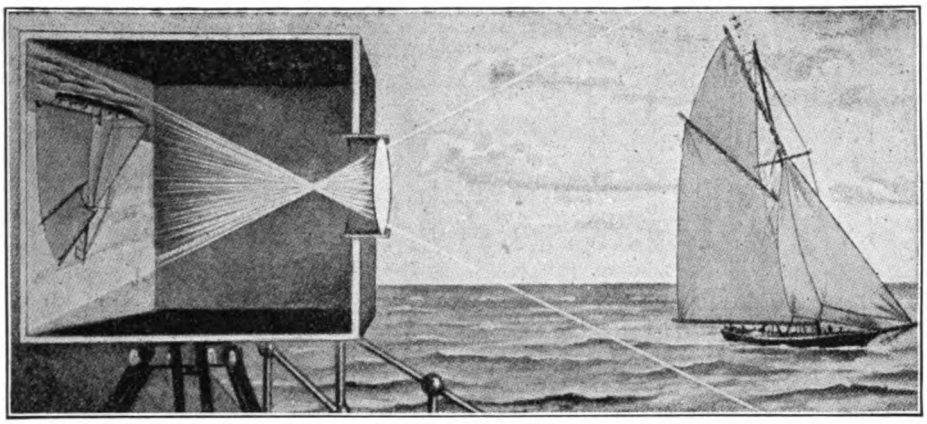


These pictures how us how a magnifying glass makes things appear larger than they really are. What happens when we look at, say, a leaf, is that rays of light are thrown off by the leaf and brought together to our eyes. When we use a magnifying glass the rays of light pass through the glass and bend—as a stick appears to bend if you put it in water, or as the pair of compasses seems to bend in the glass of water shown on this page. When the rays of light reach the eye, the eye imagines that they have come in straight lines, and it appears to the eye that the light comes in lines as shown by the dots in this picture. What we really see are rays of light. These rays not being able to go straight through a magnifying glass as if it were a piece of ordinary glass, are bent in passing through the glass, and what happens then is as if the eye having collected all these rays to a point, throws them out again in straight, sloping lines, at the end of which we see the image, looking much bigger than it really is. So that what we see through a magnifying glass is not the actual leaf but the rays of light thrown off by the leaf, first bent by the glass and then straightened out again so as to appear to cover a much bigger space. A curious thing happens if the rays of light are allowed to continue beyond the eye instead of being focused by the eye. We can do this with the aid of a microscope, as shown in the bottom picture. In this case we see the leaf upside down. This is because the rays of light meet, and then as the rays must go straight, the line of light coming from the top of the leaf goes down while the line coming from the bottom of the leaf goes up. In the top picture the meeting or focusing of the lines of light takes place inside the eye, but in the picture below we see the rays focused through the glass instead of inside the eye, and we see them, therefore, continuing, until they are reflected in the looking glass, where we see the enlarged picture upside down. This helps us to understand what happens inside the eye, as explained on the next page.

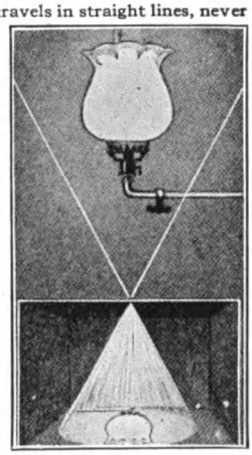


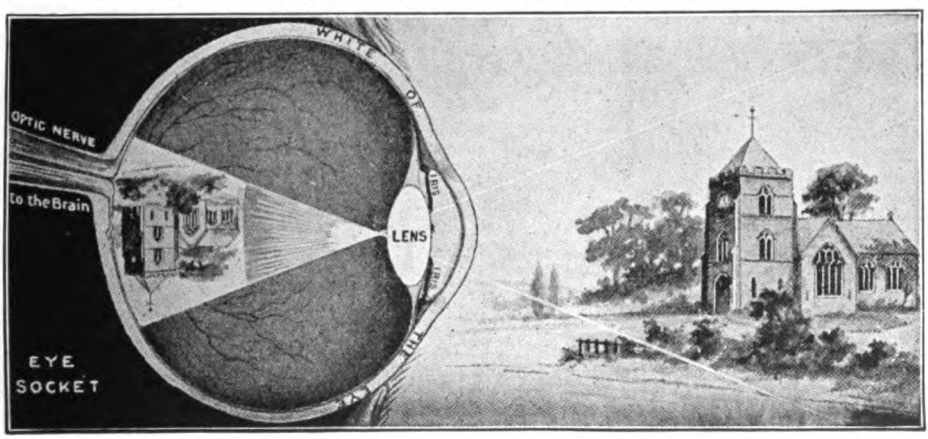


HOW THE CAMERA TAKES YOUR PHOTOGRAPH



These pictures show us how a camera takes a picture, why it takes the picture upside down and also how the eye is like a camera in this way. The boat in this picture gives off rays of light which strike in all directions. Some of these rays go out towards the camera, and as light always travels in straight lines, never crooked ones, all the rays that can be seen from the lens of the camera travel straight up or down towards the lens. Inside the lens they continue traveling in the same direction and at last they meet and cross so that the lines of light given off by the top of the boat strike the bottom of the photographic plate and the lines given off by the bottom of the boat strike the top of the plate. The small picture on this page shows a way in which any boy or girl can find out how the lines of light cross so as to make an image upside down. Take a white cardboard box without the lid and prick in one side a small hole with a pin Hold the box, say, under a gas jet so that the gas will reflect through the hole. The hole will then act as a focus of the rays which will enter the box through the hole and cross, so that the inside of the box where they fall will reflect the gas jet, which will be upside down. The bottom picture shows us that the eye acts in the same way as the camera but a very wonderful thing happens in the eye, that no man quite understands. When the photographer finds that his picture is upside down he turns the plate the other way and everything is right. But what wonderful thing is it that turns the picture printed inside the eye the right way up? The rays of light stamp themselves upon the retina of the eye as seen in this picture and the nerve of the eye carries them to the brain. What happens there nobody knows but when the brain brings together these rays of light so as to make a clear picture, the picture is the right way up. The picture is printed on the retina of the eye upside down, but our brain puts it right in the millionth part of the twinkling of an eye, and this is, perhaps, as great a miracle as anything that ever happened.





WHY A WHEEL STOPS

One of the reasons why a wheel stops when it has once been started is the resistance of the air. But wheels also stop through another kind of resistance, which is called friction. The wheel of a bicycle, for instance, travels round and round on something in the center of it, which we call the axle, and as the wheel rubs against the axle it is made to go slower. If you put your finger on your arm and rub it along your skin and press a little, you can see how you are opposed by friction; but if you put some oil on the tip of your finger first, the finger will slide along your arm quite easily, because the oil lessens the friction.

For exactly the same reason you have to oil the bearings of a bicycle. Perhaps you know that a special way has been found in which to lessen the friction of a bicycle, so that, after you stop pedaling, the wheels will go on running much farther than they otherwise would. A number of tiny steel balls are put between the axle and the wheel, so that the wheel really runs on these little balls. This is what is called "ball bearings," and every bicycle has them, both for the wheels and for the pedals.

COULD A TOP SPIN FOREVER?

Friction also helps to stop a top, but if you spin the top on a perfectly smooth plate, so that there is very little friction, it will spin much longer; and if you could spin the top on a smooth plate inside something from which you had taken away all the air, it would not be difficult to get the top to spin for hours, because things which have once started moving go on moving until something stops them. If the top could be spun where there is no air at all, and nothing happened to hinder the spinning, the top would certainly go on forever. The earth is like a great wheel or top spinning round and round in space, but, as space is almost empty, and as the earth's air is part of the earth and goes round with it, and as the earth is not spinning on anything, as a top spins on a plate, the earth scarcely slows down at all throughout the ages.

HOW FAST A WHEEL CAN GO ROUND

You might think that if you applied sufficient force to a wheel—say, the wheel of some kind of engine that was driving something—it would go round faster and faster, and there need be no limit at all to the speed at which it went round. But that is not true, and sometimes when men forget it and make wheels go round too fast, accidents happen. If you take an umbrella that has been out in the rain, and twirl it round very gently and slowly, the drops of rain will hold on to the umbrella tight enough to go round with it, but directly you spin the umbrella a little faster, the drops of rain, as you know, fly off from the umbrella. As long as the umbrella went round slowly, the force of sticking, or cohesion, as it is called, was sufficient to make the drops stick to the umbrella, but when the umbrella went round a little faster, the force of cohesion could not keep the drops sticking to the umbrella, and so off they fly. But now, after all, it is nothing but cohesion that makes the parts of a wheel stick to each other, and if the wheel went round quickly enough, this cohesion would not be strong enough to hold the wheel together, any more than it is strong enough to hold the drops to the umbrella if spun quickly.

COULD A WHEEL FLY OFF AN ENGINE

Sometimes when an engine has been running too quickly, a great wheel, perhaps made of heavy steel, has flown to pieces. These pieces have gone flying out just as the drops do from a spun umbrella, and sometimes these

have done terrible damage. This applies to everything that spins—the earth, or a wheel, or a top. There is a limit to the speed at which it can spin without flying to pieces, because there is a limit to the power of cohesion, or holding together, and directly that limit is passed, the pieces of the wheel, or the top, or the earth—if the earth were set spinning too quickly—must fly away. For everything that is moving tries to move in a straight line, and the reason why a wheel can spin at all is that the parts of it move in circles instead of in straight lines, because they are held by cohesion; but if cohesion is not strong enough, all parts of the wheel, like the drops on the umbrella, will start moving in straight lines instead of in circles, and the wheel will fly to pieces.

WHAT MAKES AN AUTOMOBILE GO

The mystery of the automobile is, of course, only the old question of using natural forces for power. In nearly all automobiles it is a gas that makes them move. In one way or another this gas is made in the engine of the car or is sent into it, and, as this gas is made under pressure, its atoms fly about in all directions, and so press upon that part of the engine which is connected with the wheels. In most automobiles gasoline is burned with air, which is admitted to the inside of the engine, and the gases which are produced by this burning make the car move. Gasoline is really a vegetable product, and has in it the power which poured upon the earth from the sun ages ago. It is really the sun, then, that makes the car move; not the sunlight of today, but the stored-up sunlight of long ages ago.

In steam automobiles the power is produced as it is in a railway engine or a steamboat. Something is burned —generally gasoline—and so boils water, and it is the water-vapor or gas that acts on the engine in this case, just as the gases made by the burning of the gasoline act upon the engine in the commoner kind of automobiles. Electricity is used in ordinary automobiles to set the gasoline burning. Each time the spark passes, a little gasoline is burned, and it is this burning that makes the noise that we hear, or part of it. The car is made to go, therefore, by a very large number of little gas explosions.

WHY SOAP TAKES OUT THE DIRT

The answer to this question has been a great deal argued by chemists, and it is a very important thing, for cleanliness is necessary, and enormous quantities of soap have to be used, and it is well that we should know how soap does its work, so that we can make the soap that works best.

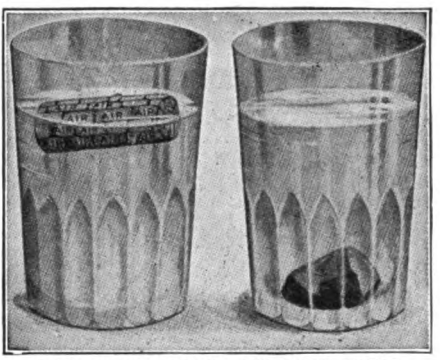
Now it is fat or oil that especially makes things dirty. If only we can melt or get rid of the oil on things, we soon make them clean, and the real use of soap is that it disposes of oil. It does this in at least two ways. Most soaps have in them a great deal of alkali. This alkali dissolves the oil that gathers on things, and makes them clean.

But soap takes the dirt from things in another way, as we know when we use soaps that have no alkali in them at all. It has the power of breaking up oil into a number of tiny little drops, which are easily washed away, together with all the dirt that the oil has collected.

A collection of tiny drops of oil, held in some other fluid, is called an emulsion. Water alone will not form an emulsion of any oil, because oil and water will not mix. That is the reason why we cannot wash well with water alone. But when water has soap dissolved in it, it is able to make an emulsion of the oil on anything we are washing, and so makes it clean.

WHY DOES A STICK FLOAT?

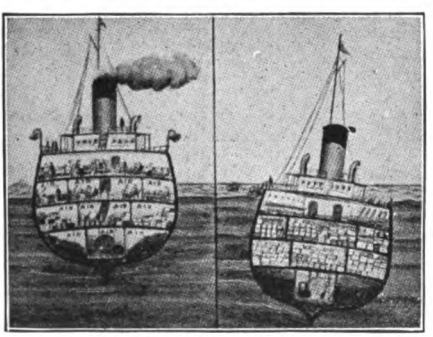
We must remember that the earth is all the time trying to pull everything to itself; it pulls us, it pulls the air, it pulls a balloon, it pulls the moon. Now, the heavier the thing is the more it is pulled, and water is heavier than



WHY WOOD FLOATS AND IRON SINKS

Wood floats because it is full of tiny quantities of air, and so is lighter, or less dense, than the water. A stone, or a lump of iron, has no air in it; it is denser than the water, and therefore it sinks. An iron ship floats because it is hollow and full of air, so that as a whole it is lighter than the water. If we filled it up solid with iron or stone, or if it cracked and so let the air escape from it and the water come in, it would sink, as shown in the second of these pictures.

a stick. This does not mean that all the water in a pond is heavier than a stick, because we know that. But it means that if you have a cup and filled it with water, and had another cup



WHY AN IRON SHIP FLOATS

the same size and filled it with stick, the cup with the water would be heavier—that is to say, in a fixed amount of space you can pack a greater weight of water than of wood. That is what we mean when we say that the water is heavier than the stick.

Of course, a pound of water is the same as a pound of stick, and you do not need to answer the question—Which is the heavier, a pound of feathers or a pound of lead? They both weigh the same, only the lead takes up less room, and so we say that lead is heavier than feathers, though a pound of lead weighs the same as a pound of feathers. The proper name for a heavy thing is dense, and, whenever it is possible, the earth always pulls the denser things further down, and the less dense things float on the top of it. That is why the stick floats; that is why the cold air is found nearest the floor, because cold air is heavier, or denser, than warm air, and the warm air floats on the top of it as the stick floats on water.

WHY AN IRON SHIP FLOATS

Men used to think that a ship had to be made of wood in order to float, because wood floats and iron sinks. But now all big ships are built of iron. Why do they not sink like a stone or an anvil? It is because of their shape. When they are hollowed out the whole space they occupy is filled with air, which makes the ship, as a whole, lighter than water, and so it floats. You can even put things into it, but the more you put in, the deeper your ship rides in the water. You can store iron in it, but if you packed it full of iron, or anything heavier than water, it would sink.

One brave man fought for years for the lives of sailors, and at last got a law made that a line should be painted outside the hulls of ships, and that the ships must not be packed so heavily as to sink that line below the surface of the water. Like everyone who does anything worth doing, he was laughed at, but his name will always be remem-

bered, and that line, which protects sailors, will always be called Plimsoll's line, in his memory.

WHAT A VACUUM IS

Vacuum is simply a Latin adjective meaning empty, and we have an English word, vacuous, which has the same meaning, and which we sometimes apply to the expression of a person's face when it seems to mean nothing—to be empty of meaning. In the study of Nature we often talk about vacuum, meaning by that an empty space. It is always necessary to remember that there is really no such thing as empty space, for what we call the ether is everywhere.

But when we speak of a vacuum we are leaving the ether out of account, and are simply thinking of gases, such as the air. We take such a thing as a globe of glass, which cannot collapse when the air is sucked out of it and we attach a pump to it, so as to suck out of it all the air we can. When we have done so, we call the space inside the glass globe a vacuum. As a matter of fact, we can never get a real vacuum, but only a space which contains comparatively little air. No one has ever made, or ever will make, a perfect vacuum.

HOW A MACKINTOSH KEEPS US DRY

A mackintosh keeps us dry because it is made of a material which water cannot get through. Our ordinary clothes are full of tiny little holes, or pores, and so we call them porous. The water runs into these little holes. and so will make our clothes wet, just exactly as it runs into a sponge, which is also full of holes, or pores—only these are so big that we can see them. But if you take a thing like a piece of india-rubber, you find that water cannot get through it because there are no holes in it to let the water through; or you can take a piece of ordinary cloth, which is porous, like a sponge, and then, if you melt india-rubber and put the cloth in it, the rubber will fill up the holes in the cloth, making it waterproof.

The name of the man who discovered how to do this was Mr. MacIntosh, and that is why many kinds of waterproof coats are called mackintoshes now. For no particular reason we have put a "k" into the word. Now, there is another kind of material which also keeps water out, or, at least, in its natural state it keeps water out, but we cut it up and put it into bottles and use it to keep water and medicine in. There is a special kind of tree which makes this cork, but really all trees have a layer of cork inside the bark, and this makes them waterproof. India-rubber is also obtained from trees.

And so, when we wear a mackintosh, we first of all take something from the coat of a sheep to make woollen cloth, and then we take something from the world of plants in order to make the cloth waterproof.

WHY AMMONIA CLEANSES THINGS

Ammonia is really a gas, but like other gases it can be dissolved in water and is more soluble in water than almost any other gas. The solution of ammonia gas in water is what we usually call ammonia, and it is largely used for cleansing things. Indeed. people add what is called, not quite correctly, "liquid ammonia," to the water of their bath, for they find that it helps to make them clean. "Liquid ammonia" is not a correct name, because what we call that is really water containing a lot of ammonia gas.

Ammonia cleanses many things far better than even strong soft soap, but it is so powerful that we cannot use it for everything. The reason why ammonia is such a splendid cleanser is that it is an alkali, and so dissolves fats and oils, as the alkalies in ordinary

soap do. But ammonia is different from all other alkalies, because it is really a gas, and the great fact about a gas is that, if it gets "half a chance," it goes everywhere. Ammonia is thus the most searching of cleansers.

WHY HOUSES ARE NOT MADE OF IRON

We are doing just what men did long ago when they passed from the "Stone Age," in which they used stone for knives and weapons, to the "Age of Metals," when they used bronze and copper and iron. We may say we are passing from the Stone Age to the Age of Metals in buildings.

Of course, in the case of a bridge, we simply use steel and do not think it necessary to do more. One of the most wonderful, though not the most beautiful, bridges in the world is the Brooklyn Bridge, which is made of steel. When it comes to ordinary buildings, however, the builder makes his building of steel; but we are not accustomed to buildings made simply of steel, and they would look very unusual to our eyes; so after he has made the steel skeleton of his house, or whatever it is, he covers it all up with stone, so as to make it look as if it were really the stone that was holding it up; yet really you might take all the stone away, and it would stand as before. The real reason for not making steel exposure is that it is such a good conductor of heat that we would roast, whereas stone or brick is a poor conductor.

HOW A BAR STAYS IN ITS PLACE

All solid things have cohesion, and we can almost imagine the tiny parts of which they are made holding on to each other, as if they had little arms or hooks. That is why things can be solid; that is why they can have a shape and keep it. You see, the earth is so enormous, compared with anything that we can make or move, that, if there were nothing else to act against the power of the earth's gravitation, everything would crumble down quite flat, so that all the stuff in it might be pulled as near as possible to the center of the earth.

A bar holds together, because, though gravitation is always acting, and is very powerful, cohesion is very powerful too. You know, for instance, the horizontal bar in the gymnasium? How does this stand? How does it come to stand so firm that it will support your weight? The answer is that, though the earth is pullling it down all the time, the earth's pull is balanced by the cohesion of the bar. If you tried to make the bar of something that has very little cohesion like sand—well, you might try for a very long time before you succeeded! Of course, it is true that gravitation acts between everything and everything else. It acts, for instance, between the tiny parts of which the bar is made, or of which the bar of sand—if such there could be—is made.

WHAT THE FIRST BUILDINGS WERE LIKE

The first devices men ever lived in began by not being buildings at all; they were just holes or caves in the earth. We have found some of these caves with bones and teeth and other things which tell us what these men ate long ago. The first attempt that man made to build was simply to make the caves that he found rather bigger and more convenient; and so he scooped them out and made them deeper, and often he scooped away much of the roof so as to make the cave higher, and let him stand and walk upright in it. And when at last man began to build for himself, he made huts, such as many peoples live in even nowadays, like the Eskimos. And these huts are really very like caves if you come to think of it.

WHO INVENTED ARCHES FOR BUILDINGS

One of the remarkable things about the great buildings of Greece is that they do not have arches. Their buildings, indeed, were in principle the same as you can make with toy bricks. Now, it is a curious thing that somehow or other, though the Greeks learned so much from the Egyptians as regards science and art and many other things, they did not know about the arch. Yet, even in very early Egyptian buildings, we find various kinds of arches, including even the pointed arch which you must have seen in many churches. There are two kinds of arches—one built up from the two sides, and then at the very top of the arch there is put in last, a stone called the keystone, because it keys, or rather locks the two sides of the arch together. People who study buildings say that the kind of arch they call Gothic does not have a keystone, the two sides meeting in a straight up and down line.

WHO THE BEST BUILDERS WERE

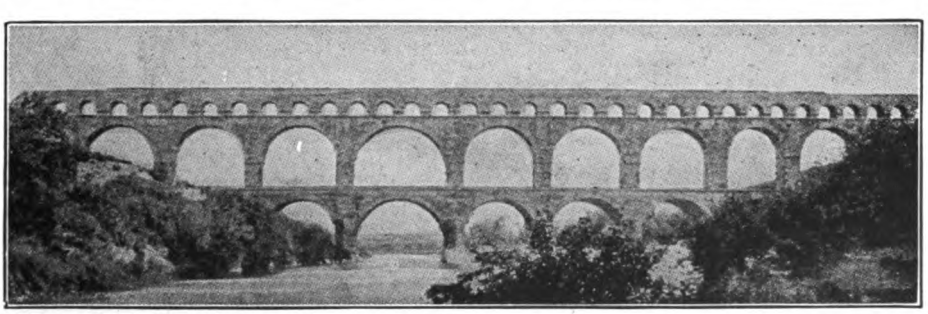
Now, you know that the Romans came after the Greeks, and that nearly everything they knew and could do they learned from the Greeks. Indeed, there was a great deal which the Greeks knew and the Romans forgot. The Romans did not build beautifully as the Greeks. There never was any building in Rome so lovely as the Parthenon. But one thing the Romans had which the Greeks had not, and that was the arch. No one appears to know whether some Roman found out all by himself how to make an arch, or whether they found arches in Egypt or somewhere else; but, at any rate, the Romans had the secret of the arch, and they seem to have been very proud of it, and used it whenever they could.

They were very fond of building what they called triumphal arches in honor of some great soldier or some great event, and you will see such arches in Rome and many parts of Italy.

In our own times we have made a great discovery as regards buildings. You know that instead of building ships of wood we build them of iron and steel. Well, we do the same thing now in building; instead of stone we use steel.

WHICH TRAVELS QUICKER—HEAT OR COLD?

Complete cold, if we could get it, would only be complete absence of heat; and what we ordinarily call cold is simply less heat than in something else with which we are comparing it. When a thing gets cold, it really gets less hot. So we cannot speak of cold traveling, unless we mean that it is a cold wind that is traveling, or cold water traveling through hot water, as when you run cold water into a hot



A GREAT LINE OF ARCHES BUILT BY THE ROMANS, WHO WERE FOND OF ARCHES IN BUILDING

bath. But we can say how fast heat travels, if by that we mean the rays of heat or radiant heat that we feel near a fire or a light. This kind of heat is really the same as light, and it travels at exactly the same speed, which you know. But cold travels at no speed, for there is no such thing.

WHAT HOLDS A BUILDING UP

We all know that mortar holds the bricks together; but we must remember that the wise builder always uses the weight of his bricks to make his building strong; and since it is the earth, with its steady pull, that gives bricks, and all other things, their weight, we must not give the mortar all the credit. No bricks and mortar would ever make a strong building if there were not the earth's pull to bind them all together.

WHY A STICK HOLDS TOGETHER

Mortar, as you know, "sets hard," like many other things—jelly and water included—if you give them a fair chance. And the power by which it, or paste or glue, holds things together is called cohesion—a word which simply means sticking together. We cannot see what really happens, but cohesion is one of the commonest things in the world. When you move one end of a stick, why does the other end move? Because of cohesion between all the parts of which the stick is made. All the parts of the stick hold together as if drawn to each other by a magnet.

WHY WE CAN'T MAKE A ROPE OF SAND

We can't make a stick or a rope of sand, and you can't build with bricks and sand. The sand has no cohesion, except just the least little bit when it is wet. Have you ever thought why sealing-wax melts when it is heated? The truth is that cohesion is one of the most important things in the world, and that the world itself, indeed, could not exist as it is without cohesion. Everything that we call solid is solid because the tiny parts of which it is made stick or hold together. A piece of sealing-wax, for instance, if it is left alone, is held together by cohesion. It does not spill itself and run all over the table, and if you lift it up by one end the other end comes too. But if you apply heat to the sealing-wax it begins to run—it begins to lose its stickiness, or cohesion. This shows a second state in which anything may be, and this state we call liquid. Running water is liquid.

WHY WATER RUNS

That is cohesion again; water runs because it has no cohesion, or else very little. While all solids have a great deal of cohesion—without which they could not be solids—liquids have very much less. But all liquids are by no means the same. Liquid water has very much less cohesion than liquid sealing-wax or liquid gum, which, indeed, has so much cohesion, or sticking together, that we appropriately call it "sticky." On the other hand, liquid alcohol or liquid air—did you know that air could be liquid like water?—has very much less cohesion even than liquid water. But there is a third state in which anything may be, and that is the state of a gas—like air in its ordinary state, and like the gas we burn for light. Now, the thing which marks a gas is that it has no cohesion at all—it runs wherever it can. However big the space that it is in, the gas always fills it. It goes under doors, out at chimneys, and out at windows, and so on. It has no cohesion.

WHY THE SMOKE OF A TRAIN GOES THE OTHER WAY

When the smoke leaves the funnel of the engine it is really moving forward, like the engine itself, and at exactly the same rate. If we could

imagine that the train was moving onwards in nothing, then, since we know that moving things always move on in a straight line at the same speed forever, unless something outside affects them, the smoke would move forward with the train, and would actually pass on in front of it as soon as the driver slowed the train. But the smoke, we know, is really poured into the ocean of air through which the train is pushing its way. The air tends to stop the train, as it tends to stop everything that moves through it, and every engineer knows how important this air-pressure is; but though it retards the train a good deal, it retards the light, hot smoke that is poured into it far more. The question reminds us that the smoke seems to go in the opposite direction to the train; but really it simply moves forward so slowly and for such a little distance that, compared with the train it seems to go the other way.

But if a strong wind is blowing in the same direction as the train—and perhaps this is oftenest seen in the case of the smoke from a ship's funnel—then the smoke is blown forward by the wind far in front of the train or ship. In this case and the last the same principle works, though the results are so different. The principle is that the air affects the smoke more than the train or ship. In one case it holds both back, but it holds the smoke back most; in the other case it blows both forward, but the smoke most.

WHY SOME FACES IN PICTURES SEEM TO FOLLOW US

You are discerning to have noticed this, and perhaps you have also noticed that in other pictures there are faces which are not looking at us; but no matter where you walk, even though it be in the direction in which they seem to be looking, you will never find the face looking at you. Indeed, faces in pictures are either looking at us, from wherever we look at them, or else they are never looking at us, from wherever we look at them. The same is true of photographs.

The rule is very simple. If the person who was being painted or photographed was looking at the painter or at the camera, then, wherever you stand, he will seem to be looking at you. If he was looking on one side, then, wherever you stand, he will seem to be looking on that side of you. This works very queerly if you have a group of people who were all looking at the camera when they were photographed. If you look at the photograph from one side, they all seem to turn to follow you, and then to turn back if you look at it from the other side. But if they were not looking at the camera, you can never get them to look at you.

HOW BURGLARS ARE CAUGHT BY THEIR FINGER-PRINTS

You have heard, perhaps, that nowadays burglars wear gloves in order to avoid leaving their finger-marks on a window-pane or anywhere else. The fact is that all men and women differ

These are the marks of men's fingers on things they have touched. Finger-prints like these help the police to catch burglars. No two finger-prints from different people have ever yet been found to be alike.

from each other in little things, and there is nothing in which they differ more certainly than the pattern of the little ridges on their fingers. Two patterns exactly the same from two different people have never yet been found. These patterns cannot change, for they are formed by the innumerable mouths of the tiny canals which convey the sweat from the deep-seated sweat-glands to the surface. They can be destroyed, of course, but no different pattern can be put in their place.

Thus, of all the ways of knowing who is who, this is the most certain, as well as much the simplest and cheapest. It is now being more and more used. If a man's thumb-mark is the same as the mark on a piece of paper where a theft was committed, the evidence against him is very strong. A bad man who has become known to the police may change his clothes and the appearance of his face, he may look like a different person, and have not the slightest resemblance to the photograph taken of him, but his thumb-mark will tell him at once. This is now known as the Bertillon System.

How many words there are in the English language

A dozen great scholars might give as many answers to this question. One of them, some years ago, gave the number as only 38,000. But a still greater scholar, Professor Max Müller, who, was perhaps, the greatest authority of his time on words, put the number of words in the English language at 100,000. He compared the growth and development of our language with the putting of grain in a sieve. Most of the chaff has been winnowed off, and with it have gone many good grains. Good old English words, which we now consider only dialect words or "Americanisms," have gone out of the language. If we include all the words which have fixed places in the dialects of the country, and include also many which we know were spoken in earlier times, we shall have to put the total at 300,000 for the English language.

That number is constantly growing. Words have to be invented for new industries, and they become part of the language. When a new dictionary was made, not many years ago, it was found that the new words necessary for use in relation to electricity and electrical appliances numbered over four thousand. A similar increase had taken place with regard to other arts and sciences. Most of them are purely technical words, but, little by little, they become common words as all of us know more about science; and so the language grows.

Have we yet discovered all the world?

No, the Arctic and Antarctic regions still possess secrets which as yet no man has been able to solve. Many brave men in fine ships went into the gloom and silence of the frozen regions in the hope of discovering the Poles; but a great many perished in the attempt. Each expedition brought back a little more knowledge; until finally both Poles were discovered. The North Pole by Peary on April 6, 1909, and the South Pole by Amundsen, on December 14, 1911. There is much land still to be explored in Asia. There are parts in the far North of the American continent of which we know very little. So, also, in the great sandy, stony heart of Australia.

The continent of Africa has been traveled from end to end, and from side to side, but we can fix a point on the east coast of Africa and come out at a point on the west coast, and cover ground which no white man has previously crossed.

THE AEROPLANE IN WARFARE

The aeroplane enables us to take real "bird's-eye" views of scenes on the surface of the earth. At first we might think that a photograph taken from an aeroplane to be a mere curiosity, but to the military expert it suggests possibilities of a startling nature in connection with the art of war. It lays bare the maneuvering of armies and the interior of fortresses; robs the decks of ships of their secrets, and it is even claimed that the movements of submarine boats are almost as patent as though they were moving on the surface of the water. So even as a scouting facility the aeroplane will be of first rate importance in the war of the future. The various governments, including that of the United States, have recognized this use to which the aeroplane may be put. The United States has an aviation school at Annapolis where students are taught the use of the aeroplane in connection with warfare. So far the chief experiments at this school have been in connection with the hydro-aeroplane, which rests on three pontoons, attached centrally and at the wing-tips, thus enabling the machine to rise from the water or settle on it with the facility of a water fowl.

Whether the aeroplane may be utilized as an instrument of destruction is a different question. Experiments have been made in dropping bombs on targets representing war vessels but it is not yet established that they can be dropped with accuracy from a swiftly moving aeroplane so as to be of practical utility. Better results have been obtained from a new machine gun invented by Lieutenant Colonel Lewis of the United States Coast Artillery. This gun weighs only twenty-five pounds and discharges 750 shots a minute and the discharge of the gun is practically without recoil. It would seem that a target on the face of the earth might be hit with considerable accuracy from an aeroplane flying at the rate of 60 miles an hour.

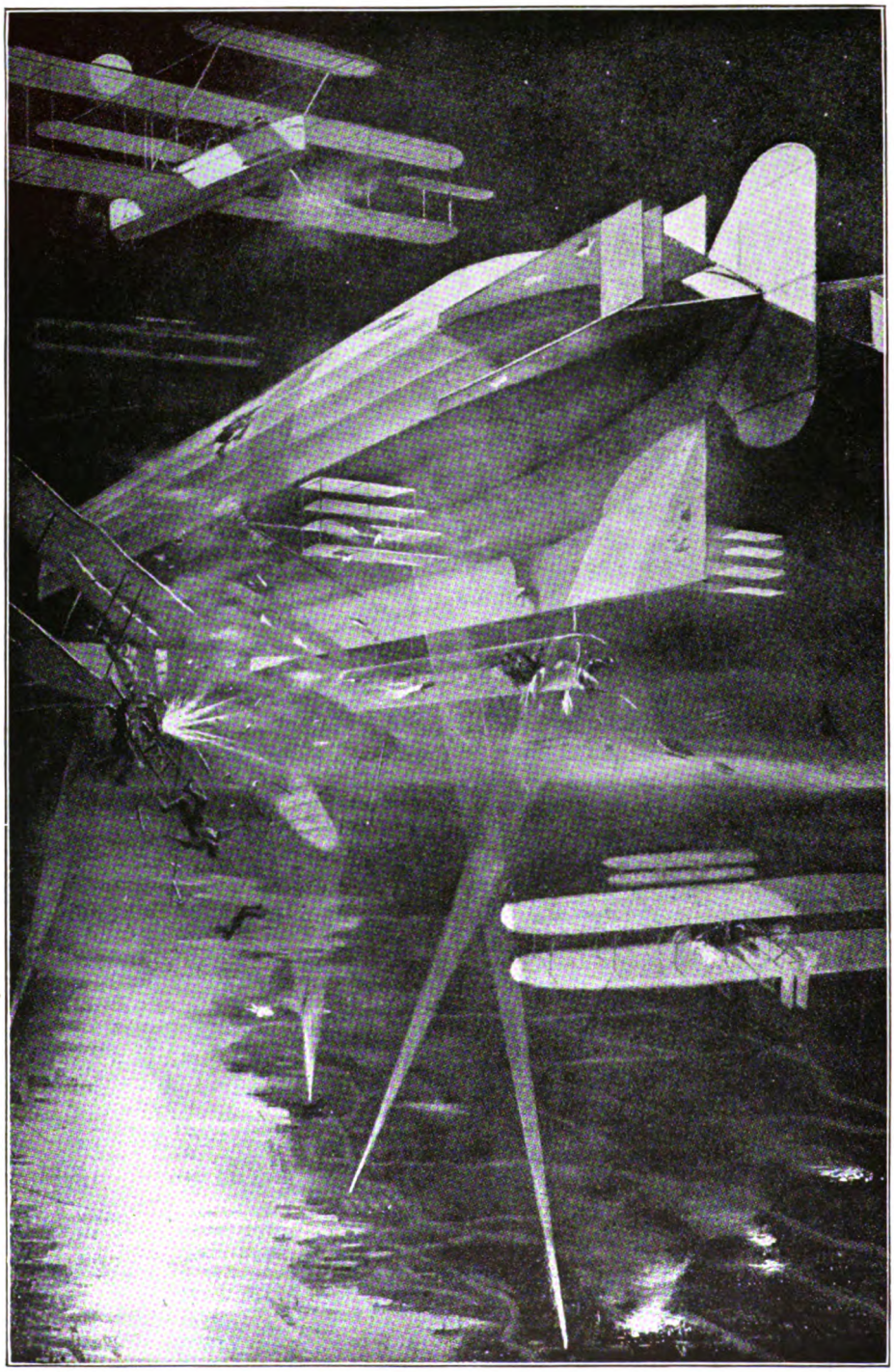
WHY THE UNITED STATES IS CALLED "UNCLE SAM"

This term is used in reference to America exactly in the same way as "John Bull" is applied to England. It arose at the time of the last war between England and America. At Troy, New York, on the Hudson, a commissariat contractor named Elbert Anderson, of New York, had a store yard. A government inspector named Samuel Wilson, who was always called "Uncle Sam," superintended the examination of the provisions, and when they were passed, each cask or package was marked "EA-US," the initials of the contractor and of the United States. The man whose duty it was to mark the casks, who was a facetious fellow, being asked what the letters meant, replied that they stood for Elbert Anderson and Uncle Sam. The joke soon became known, and was heartily entered into by Uncle Sam himself. It soon got into print, and long before the war was over was known throughout the United States. Mr. Wilson, the original "Uncle Sam," died at Troy, in 1854, aged 84 years.

HOW THE AMERICAN FLAG ORIGINATED

The United States Congress passed a resolution on June 14, 1777, declaring "that the flag of the thirteen United States be stripes alternate red and white; that the union be thirteen stars, white in a blue field, representing the new constellation." In 1794, Congress decreed that after May 1, 1795, "the flag of the United States be fifteen stripes, alternate red and white, and that the union be fifteen stars, white in a blue field." This change was made to mark the admission of Ver-

AIRSHIP ATTACKED BY AEROPLANES WHILE BOMBARDING A NAVAL BASE



Stationed in harbors and housed in floating sheds, coast defence aeroplanes must be ready to give battle in their own element to such aerial invaders as may dare to approach their shores.

mont and Kentucky into the Union. The stars and stripes were then equal and a star and stripe were to be added with the admission of each new State. It was realized, however, that the addition of a stripe for each new State would soon render the flag too large, and a resolution was accordingly passed by Congress, April 4, 1818, reducing the number of stripes to thirteen—representing the original Union—and making the stars twenty in number. It was, furthermore, enacted that a new star should be added for each new State admitted into the Union.

The first American flag, known as the "Stars and Stripes," was, according to our best information, made by Mrs. Betsy Ross of Philadelphia, about whom succeeding years have thrown a glamor of patriotic romance.

The official flag of the United States bears forty-eight white stars in a blue field, arranged in six rows of eight stars each. Two stars were added in 1912 by the admission of Arizona and New Mexico to the Union. The garrison flag of the Army is made of bunting, thirty-six feet fly and twenty feet hoist, thirteen stripes, and in the upper quarter, next the staff, is the field or "union" of stars equal to the number of States, on blue field, over one-third length of the flag, extending to the lower edge of the fourth red stripe from the top. The storm flag is twenty feet by ten feet, and the recruiting flag nine feet nine inches by four feet four inches. The "American Jack" is the "union "or blue field of the flag. The Revenue Marine Service flag, authorized by act of Congress, March 2, 1799, was originally prescribed to "consist of sixteen perpendicular stripes, alternate red and white, the union of the ensign bearing the arms of the United States in dark blue on a white field." The sixteen stripes represented the number of States which had been admitted to the Union at that time, and no change has been made since. June 14, the anniversary of the adoption of the flag, is celebrated as Flag Day in a large part of the Union.

WHAT ARE THE THREE FLAGS IN THE UNION JACK?

The Union Jack is made up of three flags—the English flag of St. George, the Scottish flag of St. Andrew, and the Irish flag of St. Patrick. St. George, who lived about 300 years after the birth of Christ, was a heroic soldier who gave up his life rather than deny his faith at the bidding of a Roman emperor. Edward III adopted his name as a war-cry for England, and the red cross of St. George on a white ground became the English flag. St. Andrew was one of the twelve Apostles, and he was crucified on a cross shaped like the letter X. Some relics of the Apostle are supposed to have been carried to Scotland, and the white cross of St. Andrew on a blue ground long ago became the national flag of Scotland. St. Patrick was carried to Ireland as a slave at the beginning of the fifth century. He lived there for thirty years, founding many schools and monasteries, and died there a very old man. Many centuries afterwards, the cross of St. Patrick became the national flag of Ireland.

WHY THE ENGLISHMAN IS CALLED JOHN BULL

Every country has a nickname, and is represented in pictures by an animal. The British lion is the animal which stands for England, and John Bull is its owner and master. The lion is the country; John Bull is the nation. The name of John Bull comes from a work written by John Arbuthnot, a witty doctor and writer, a great friend of Swift and Pope. He was born in

BIRTH OF THE AMERICAN FLAG

This picture shows Betsy Ross and her assistants making the first American flag at her home in Arch Street, Philadelphia. The flag was first hoisted over a military post at Ft. Schuyler, N. Y.

1667, in Scotland, and died in 1735. The sketch that he wrote dealt with the political affairs of Europe at the time, and the countries were made to appear as if they were men and women.

HOW THE AMERICAN INDIAN REACHED AMERICA

This is a much discussed question. In a recent paper Prof. Chamberlain coincides with the more common opinion that the American race came from Northeastern Asia across Bering Strait. However, he does not think that the Indian came from an existing people of Northeastern Asia, but thinks that they came from a Mongolian race which migrated at a very remote period; that they changed considerably in their habitat and that after many ages there was a migration in the opposite direction from America to Asia, thus Americanizing a large portion of Eastern Siberia. The red race and the yellow races of Northeastern Asia including the Chinese and the Japanese, would appear to be akin. This view is largely confirmed by a similarity of facial contour, or hair and eyes and of complexion, and by the fact that the two races are very similar in their mental traits.

But there are others who take a different view: Prof. Ameghino of Argentina, and Prof. Sergi, an Italian anthropologist, believe that the Indian is descended from the South American monkey.

WHERE THE ALPHABET CAME FROM

No one really knows all about where the alphabet came from, because it grew very slowly, like children and like every other good thing in the world. But we know quite well that no ingenious man sat down and made the alphabet, and we know quite well, too, that the alphabet began as pictures.

Just as a child reads or takes things in by pictures long before it can read letters, so men used to read and write by pictures; and then these pictures were gradually made simpler and simpler, until at last they could be used in every and any way, as our letters can. We know for certain that the letter O was at first the picture of an eye, and that gradually men made the picture simpler and simpler, until at last they just drew an O. We know for certain also that the letter I was once the picture of a man standing, and many people think that the letter A was once the picture of a house; and very likely a capital A may have been at first the picture of a pyramid.

Ages and ages ago in Egypt men used both kinds of writing. The priests used the oldest kind, which were the pictures. This was called the sacred writing. But the ordinary people used a different and newer kind of writing, in which the pictures were turned into letters. Not very many years ago, men tried in vain to read the old sacred picture writing of the Egyptians, but they could not. Then they found the wonderful Rosetta stone, and this had written upon it the same thing three times—once in the pictures and once in the letters, and also once in other letters, and so men got the key to the picture-writing, and now it can be read easily.

HOW MANY WORDS MOST OF US USE

We need not tremble at the number of words it is possible to use. Our greatest writers find quite a small number sufficient for their purpose. Shakespeare, with all his varied writings, used only about 15,000 different words. Milton needed only 8000 different words for "Paradise Lost," while the Old Testament contains fewer than 6000 different words. Some people use only about 800 different words, and most of us use no more than one or two thousand.

The beauty of writing and speech

lies not in the number of words used, but in the choice and placing of them. Simple language is the most beautiful. The finest English writing is in the Bible, in "Robinson Crusoe," and in "The Pilgrim's Progress," and in each of these books the language is so simple that a child may understand, while great scholars find equal delight in it.

WHY WE HAVE NAMES

Well, we have names for the same reason that everything has a name. If we did not have names, we should have to have numbers, like the numbers on motor-cars, which serve just the same purpose. Now, there are names which have meanings, and there are names which have none, and it is always well to know how much and how little a name means. There is something which we call electricity, which means really that it has something to do with amber, for when you rub amber you get electricity, but people sometimes speak as if the name explained electricity, or as if it explained something else to say that it was electricity. That is because they do not know how little the name means. We might just as well call electricity X—which is the name in what is called algebra for an unknown quantity.

One thing you ought to know, however, is the meaning of your own name. If your name is Theodore, for instance, you ought to know that that means the gift of God. Many of our names have meanings, which you can sometimes find in the Bible.

WHAT THE CINEMATOGRAPH IS

Cinematograph simply means "moving picture." You take a camera, and run through a number of films one after the other, perhaps at the rate of forty or fifty in a second. Perhaps the camera is looking at the sea, or at a game of football. Then, if you take a magic-lantern, and run the film through it at the same rate as you ran it through the camera in the first place, you can throw a moving picture upon a screen. The eye remembers each separate picture after it has gone just long enough to blend it in your brain—where your real eyes are, at the back of your head—with the next picture that comes along; and so you see the waves or the procession as if you were looking at the real thing.

WHAT THE CINEMATOGRAPH TEACHES

We can learn from our senses even when they deceive us. If the eye did not deceive us so as to make us think we see things for a tiny part of a second after they are gone, the cinematograph would merely perplex and tire us, and would not give us the effect of reality at all. Now, too often the cinematograph was used for silly purposes. But some wise people are teaching us by it. For instance, students can learn how a great surgeon performs an operation a thousand miles away by seeing a living picture of him at work. And men have taken living pictures of wild birds flying home to their nests over the water, the parent birds feeding their young ones, the young ones learning to fly, and so on. Other men have taken pictures of terrible things which we ought to know about, so that we can stop them. Yet other men have made living pictures of the blood running through the little tubes in the web of a frog's foot, so that thousands of people at once can see with their own eyes what the circulation of the blood is, and how the little blood cells tumble over each other as they scurry through these tubes, carrying oxygen from the frog's lungs to every part of its body—just as our blood does for us. Before very long the cinematograph will be used all over the world for teaching, as the blackboard is today!

MISCELLANEOUS QUESTION BOX

Why does a ball bounce?

A ball bounces because its elasticity makes it tend always to spring back into shape whenever flattened. When it strikes some hard object the ball is partly flattened by the impact. It resumes its former shape with such speed as to cause a recoil or bounce. The harder the ball strikes the more it is flattened and the more violent the rebound.

Why does wood warp in damp weather?

When wood is alive it instinctively expands in wet weather, to admit the moisture on which it thrives. Wood that has been cut retains that tendency. It absorbs moisture only across the grain. This causes the expansion known as "warping."

Why are shoes hotter when they are dusty?

Dull or dusty shoes absorb the heat. Brightly polished shoes throw off the sun's rays by reflection.

Why is toast more digestible than bread?

The charcoal on the toast's surface helps to absorb the stomach's acid.

Why does wood decay?

The presence of myriads of parasitic microbes causes wood to decay. The soaking of wood in creosote prevents the microbes from carrying on their work of destruction.

Why are there two buttons on the back of an evening coat?

This fashion dates back to the days when every well-dressed man wore a sword. The two buttons on the back of the coat held the sword belt in position.

What is pumice stone?

Pumice stone is volcanic. It is formed deep in the earth and thrown out upon the surface from volcanic craters.

What was the origin of the word "Lullaby?"

Lilith, according to the legend, was Adam's first wife and was a demon. Mothers, soothing their children, would croon the words "Lilith abi" (meaning, "may Lilith keep away from you!") The phrase became corrupted to "Lullaby."

Why does dampness make wood decay?

The oxygen of the water combines with the wood's carbon and forms carbonic acid. The hydrogen of the wood is oxidized and decay sets in

Why does a silver dish tarnish more readily than silver bullion?

An alloy is used to make such vessels harder and more lasting. This alloy oxidizes more quickly than the pure silver.

Why are glue and paste adhesive?

The water used with them evaporates rapidly. They insinuate themselves so closely into the pores of the substance to which they are attached that when the water dries the whole mass becomes solid.

Why does the exploding of a cartridge cause a report?

The sudden release and expansion of imprisoned air causes a partial vacuum. The report is caused by the inrush of fresh air to fill this vacuum.

Why does dry wood burn more easily than green?

The dry wood's pores are filled with air, which helps combustion. The green wood's pores are filled with moisture, which tends to put out the fire.

Why is a crowded hall likely to be struck in a thunder storm?

The vapor and heat rising from so many bodies make the hall a good conductor of lightning.

Why won't a polished tin pan bake bread as readily as an iron one?

The bright metal reflects the heat and will not readily brown the crust on the sides and bottom of the pan. Thus the top of the loaf tends to burn before the sides are brown.

What is the origin of pin money?

Pins were once very expensive. Women bought them as a luxury with their extra money. Hence, money to buy luxuries became known as "pin money."

Does a fan cool the air?

No. It makes the air slightly warmer by imparting to it the heat from the face of the person fanned.

What substances go to make up common glass?

White sand silicate, soda ash, lime hydrate, a little antimony, arsenic.

How did the phrase "a feather in his cap" originate?

In Hungary an ancient custom forbade any man to wear a feather in his cap until he had slain at least one Turk. Hence the presence of such a feather was a sign of prowess.

What is the effect of electricity upon water?

The water is reduced to its elements—two parts of hydrogen to one of oxygen.

Why is oak wood stronger than pine?

Because the molecules of the oak have a greater power of attraction for each other and so would take a greater force to separate them.

How long must a pendulum be to vibrate sixty times a minute?

The length of the pendulum that vibrates just sixty times a minute is 39.1 inches in New York; this varies at different points on the earth's surface.

How is stoneware glazed?

By throwing common salt into the furnace. This is volatilized by the vapor of water, which is always present, and the silica of clay of which the air is composed. This fuses over the surface of the ware and gives a thin but excellent glaze.

What becomes of the abundance of carbonic acid gas from the cities?

Some of it is absorbed by vegetables, the rest is blown away by the wind and diffused through the whole volume of the air.

Why does saleratus make cake light, particularly if mixed with sour milk?

The acid of the milk disengages the carbonic acid contained in the saleratus.

Why does mortar become hard after a few days?

The lime reimbibes from the air the carbonic acid which has been expelled by fire, and the loose powder again becomes as hard as the original limestone.

Why does an extinguisher put a candle out?

The air in an extinguisher is soon exhausted of its oxygen by the flame, and when there is no oxygen the flame goes out.

What are meant by latitude and longitude?

Latitude is the distance north and south of the equator. Longitude is the distance east or west of the line of Greenwich near London.

What is the weight of a cubic foot of gold?

About 1200 pounds.

How long ago was shorthand used?

Shorthand probably originated in Greece or in the Orient. It is known to have been in common use in Rome as early as 63 B. C. and was employed by Tiro, Cicero's secretary, to report his master's speeches in the Roman senate.

Why are the edges of gold and silver coins "milled?"

Silver and gold coins used to be "pared," or scraped at the edges by unscrupulous people, who collected and sold the fragments of precious metal thus obtained. To prevent this the edges were "milled." Copper and nickel are not of sufficient value to make "paring" worth while, So copper and nickel coins are not milled.

Why is ice slippery?

Ice is slippery because the molecules of water are held together so smoothly and evenly that no resistance or friction is offered.

What were the seven wonders of the world?

The pyramids of Egypt, the hanging gardens of Babylon, the temple of Diana at Ephesus, the statue of Olympian Jupiter at Athens, the Mausoleum, the Colossus of Rhodes, the Pharos (lighthouse) at Alexandria.

Why are three gilt balls used for pawnbrokers' signs?

The Medici family of Florence were money lenders. Their coat of arms bore three gilt balls.

What is the derivation of the word "spinster?"

In olden days a woman did not marry until she had spun a full set of household linen. Thus, till they were married, they were known as spinners or spinsters.

Where did the United States get the decimal system of coinage?

Gouverneur Morris in 1782 reported to congress a decimal system of currency, using as a basis the 1140th part of a Spanish dollar, which, he calculated, was a common divisor of the various currencies. With this fractional sum as a unit he laid out a monetary system. Jefferson in 1784 improved on this by suggesting four standard coins—$10, $1, 1 dime and 1 cent.

When and from what country was the wearing of orange blossoms by brides introduced into Europe?

From Syria, at the time of the Crusades.

How did the custom of throwing shoes after a departing bride originate?

The dropping of a shoe on a piece of property was once a symbol of new ownership. By throwing shoes after a bride her parents signified that they gave up all claim to her.

What is the origin of the word "hurrah?"

It comes from the Slavonic phrase "hu-ray," meaning "To Paradise!" This was a battle cry among the Slavs.

Why are members of tropical races dark-eyed?

The dark color defends the eyes from the intense heat of the sun, which would otherwise scorch them.

Why does paint keep iron from rusting?

Paint prevents the moist air from coming in contact with the iron.

Why is it hard to write with ink on greasy paper?

Grease will not readily mix with water or ink and prevents the ink from being properly absorbed by the paper.

What is the origin of the ring in the marriage ceremony?

Its use began in Egypt, and then, as now, signified a transfer of property—"With all my worldly goods I thee endow."

What good effect has rain falling on dead leaves?

It hastens the decay of the leaves, thus helping to fertilize the earth.

How is the red fire in fireworks produced?

By nitrate of strontian, which burns with a red flame.

What are the uses of cast iron and steel?

Cast iron, being brittle, is used chiefly for stoves, furnaces, etc. Steel's superior hardness and flexibility renders it useful for making springs, tools, etc.

Why does mother-of-pearl show so many colors?

It consists of many transparent layers overlapping one another and thus forming grooves that run in all directions. The grooves act as prisms, in which various colors are seen.

Why are dreams usually illogical and absurd?

The cerebrum (the reasoning part of the brain) is at rest during sleep.

What is German silver?

It is an alloy of copper, zinc and nickel.

What are three forms of iron?

Wrought iron, cast iron and steel.

What are the most important uses for common salt?

As a part of the diet and for freezing mixtures and for purposes of manufacture.

What are the different kinds of coal?

Anthracite (hard) and bituminous (soft). Forms of coal in transition state are lignite and peat.

How are mirrors made?

They are of plate glass, backed by an alloy of thirty parts mercury and seventy parts tin.

What is plaster of paris?

Gypsum is heated and afterward powdered. This produces plaster of paris.

Why is rain water better than any other for plants?

It contains carbonic acid and ammonia, which serve as fertilizers.

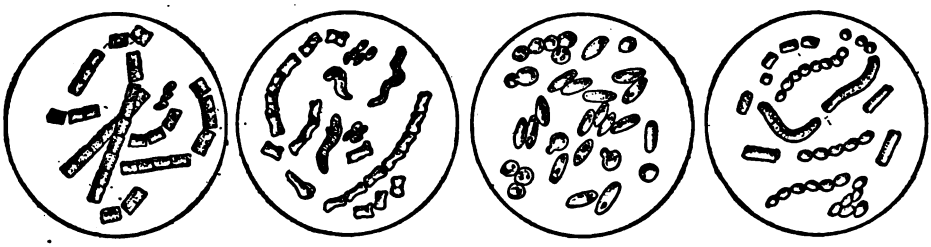
What is shale?

Shale is a form of slate that splits easily into thin, brittle layers.

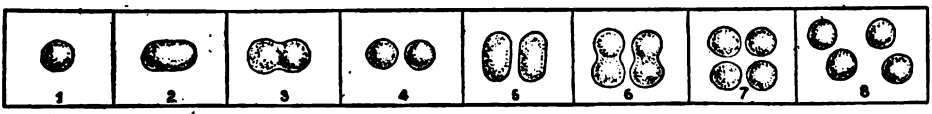
THE INVISIBLE ARMIES THAT MASTER THE EARTH

These pictures show us what is going on in our bodies almost every moment we live. Our bodies are inhabited by millions of living creatures, always fighting to make us ill or keep us well. In the first circle we see the little white things, called phagocytes, that live in our blood and keep it pure; in the second we see them devouring microbes which do us harm. The third circle shows the growth of a microbe. The small rings are the seeds, which grow together like a little stick and split up. The long, thin things that are growing out of them are the things they move with, what we should call legs and arms. The last picture shows what a colony of microbes looks like, and we see separate microbes going out to form other colonies.

This is a row of our microbe-enemies, shown 1,000 times bigger than they really are. The first are the microbes that cause cholera, the second cause consumption, the third cause typhoid fever, and the last cause lockjaw. These powerful creatures are so small that 140,000 could be placed side by side on a line as long as a pin.



This is a row of our microbe friends, shown 1,000 times bigger than they really are. The small microbes at the top in the first circle make milk sour; those below help to make butter and cream. In the second circle are the microbes found in yeast, which make alcohol; in the third is the microbe that makes vinegar; and in the last circle is a microbe that helps to make cheese. We could not live without such microbes as these.

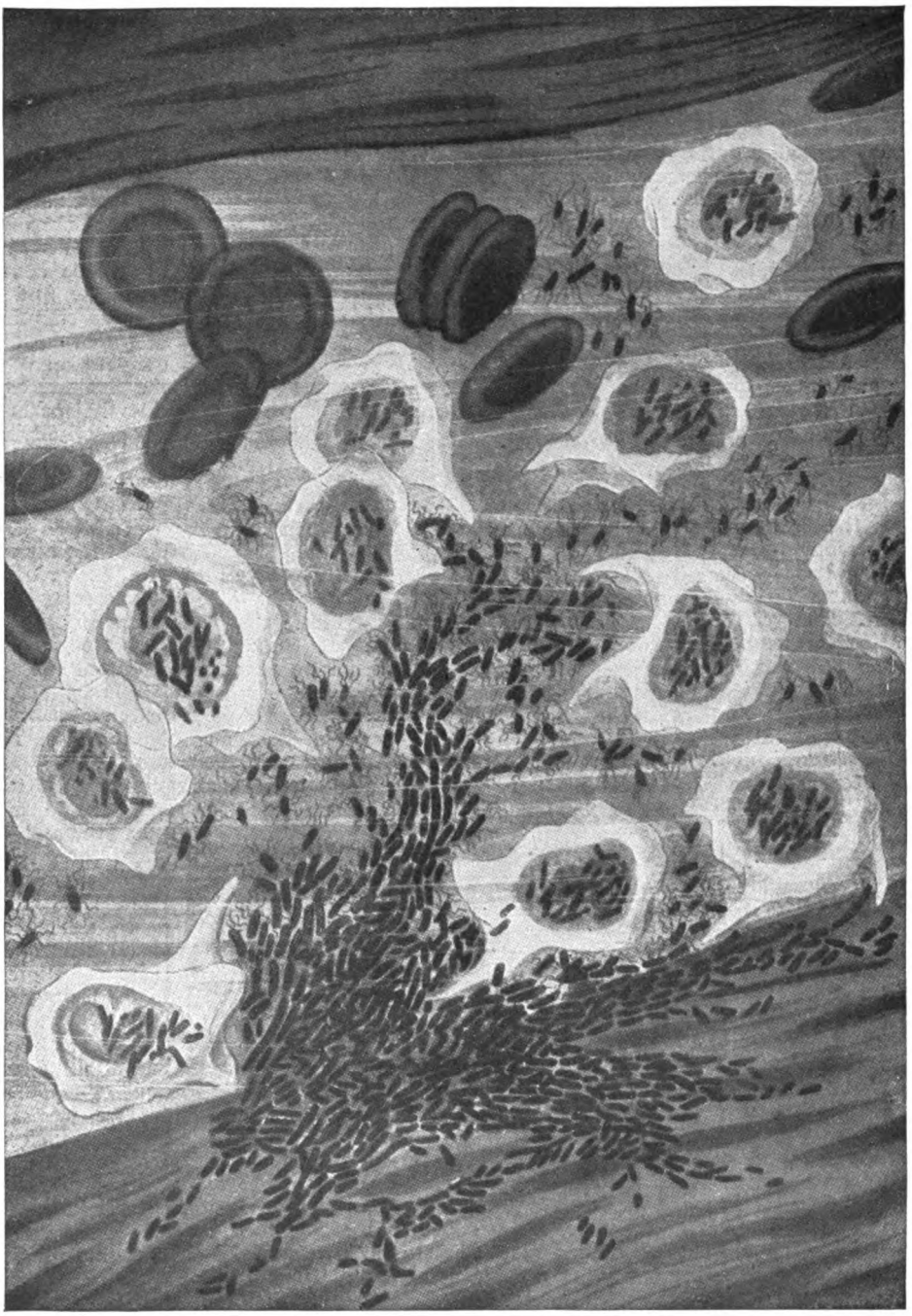


A microbe beginning | About five minutes later | After 15 minutes | It grows into two | Both begin to develop | Both form "waists" | The two become four | At the end of an hour

Microbes cannot be seen without a magnifying glass, but we can watch them working with a microscope.

THE WONDERFUL WAY IN WHICH MICROBES ARE BORN WHILE WE LOOK AT THEM

These pictures show the way microbes grow. Some form a "waist" and add other microbes to themselves like a string of beads. Others form buds, which break off and become separate microbes. Others join together in long rods and break off afterwards. And so these little creatures grow, more quickly than any man can count. In 24 hours, if they all lived, the children of one microbe would form a line reaching from end to end of England, and if the microbes were as big as shown here this line would be long enough to go 20 times round the earth.

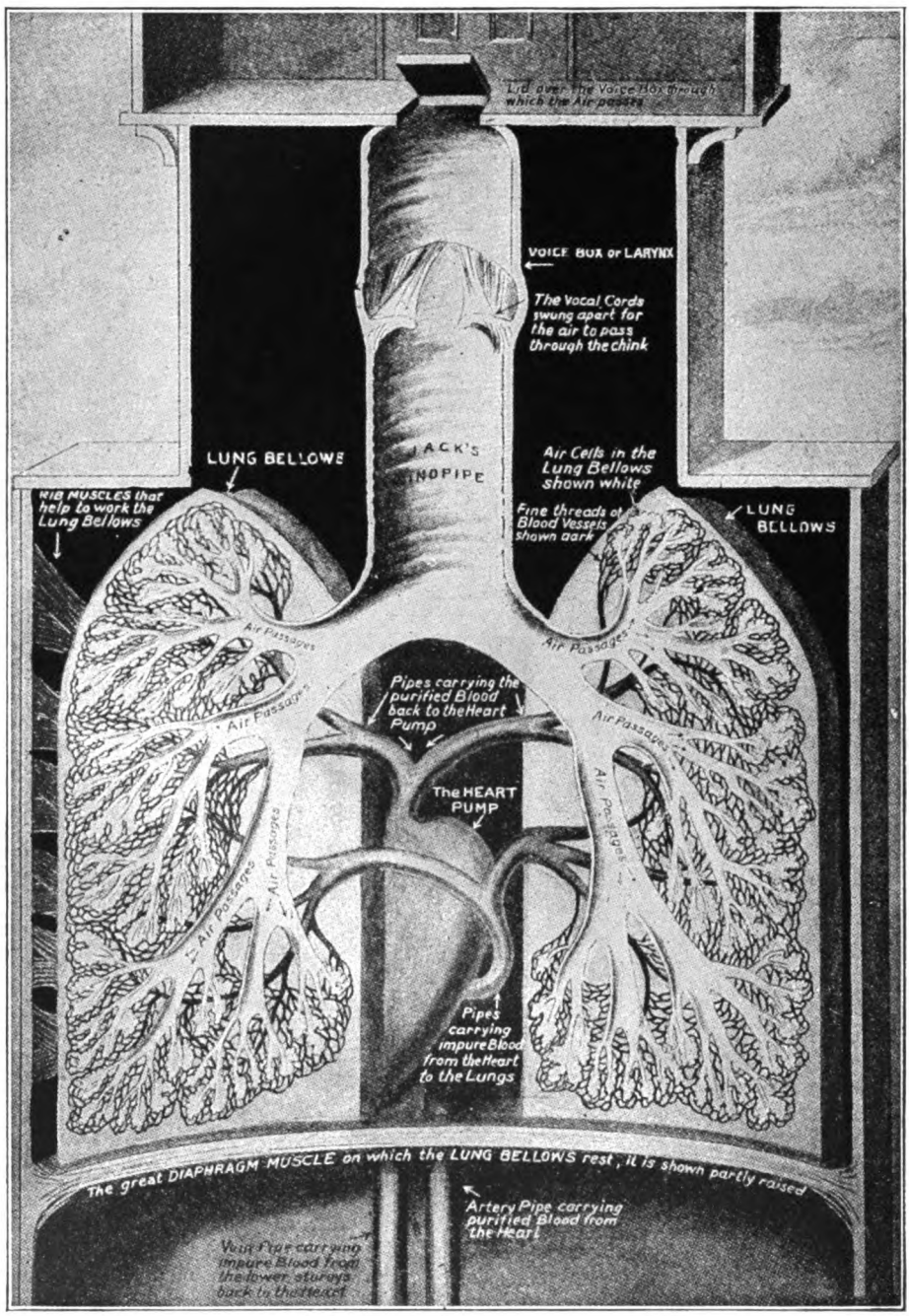


This shows what happens in a drop of blood when we are ill. The little black "burglars," invisible to the eye, are phoid fever para-ites, and the white cells of the blood are attacking them. If the white cells win the battle, we recover; if they lose, we die. We see this under the microscope.

BOOK OF OUR OWN LIFE

Our Body a Human House
Story of the Eye
Parts of the Eye
Seeing Colors
The Marvel of Hearing
Balancing the Body
Talking and Singing
Smell and Taste
The Forest of Nerves Within Us
Mystery of the Brain
Parts of the Brain
How to Remember
How We Think

THE VENTILATION OF THE HUMAN HOUSE



In this picture we see how the human house is ventilated. The air goes down the voice-box and windpipe and into the lungs, or bellows, which are very much like sponges, with thousands of tiny hollow spaces lined with living cells. These cells lie between the air and the blood in the hollow spaces, and they purify the blood by taking the oxygen from the pure air and sending it into the blood, and by driving the carbonic acid gas and water from the blood into the air, to be breathed out again. The impure blood is always being pumped through the lungs to be purified in this way. In the picture the blood-vessels of the lungs are shown dark, and the air-passages light.

THE BODY A HUMAN HOUSE

THIS human house of ours is the home of the soul. It is the wonderful and mysterious home which God provides for each of us and of which we should learn to take the best of care.

Just as with houses built of timbers or of stone, so this house of ours is made up of many rooms. Each room renders its special service and demands of us in turn, a special care. When we are hungry, the stomach room, or Great Furnace of our house is in need of wholesome food. This food after undergoing a wonderful change is absorbed by the blood, and then through a net-work of arteries and veins is carried to the skin, the nerves, the muscles, and the bones, and thus nourishes and builds up our body.

NEED OF FRESH AIR IN THE HOUSE

But food alone cannot make this house of ours a healthy place in which to live. The lungs, the Ventilators of the house, must be filled and refilled many times each minute with pure, fresh air. The air breathed deep into the tiny cells of our lungs, meets and purifies the impure blood which has been sent there by the heart, the Great Pump of our house. This Great Pump of our house is kept busy every minute of our lives: First, it must gather the poisoned and waste-laden blood from every part of the body and send it to the lungs; then with tremendous force the pure blood is pumped through the arteries and the veins on its long journey to every part of our body. Sometimes, Enemies, or invisible living things called Microbes, creep into our house and try to steal away our health, but wholesome food, fresh air and an abundance of sunshine and exercise will drive these Enemies away.

THE BUSY SENTINELS IN THE FIRST STORY

The top story of our house is supplied with busy sentinels, the eyes, the ears and the nose, which are always on guard to protect our house against its Enemies. For example, if we breath through the nose, the air is tested and filtered of impure particles; what we carry to our mouths is closely examined and tested by our tongue before it is admitted to the stomach; and the knowledge thus gained from touching and tasting and smelling helps train the outer sentries, the ears and the eyes to be on guard, and to warn of approaching danger.

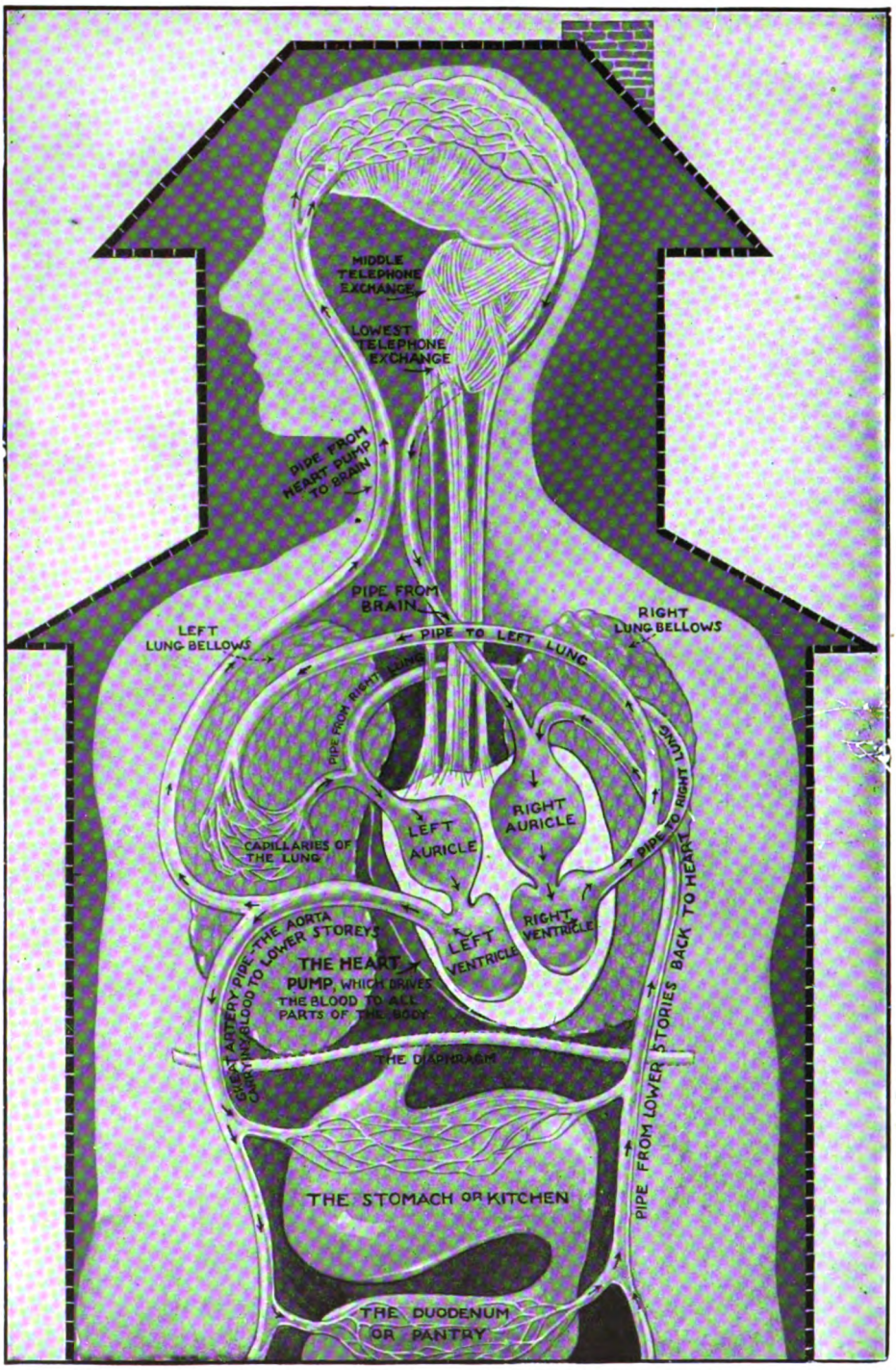
OUR TELEPHONE EXCHANGE, THE MASTER OF OUR HOUSE

We may correctly call the Brain our Telephone Exchange. It is connected with every room and every part of our body by a network of nerve fibers —Telephone Wires. These nerve fibers are usually gathered into insulated cables called nerve trunks, and over these nerve trunks travel the lightning messages to and from the brain, the master of our house. In this same manner the sound vibration travels over the Telephone wires that extend everywhere throughout a city and unite at the central exchange.

A WONDERFUL STORY MOST WONDERFULLY TOLD

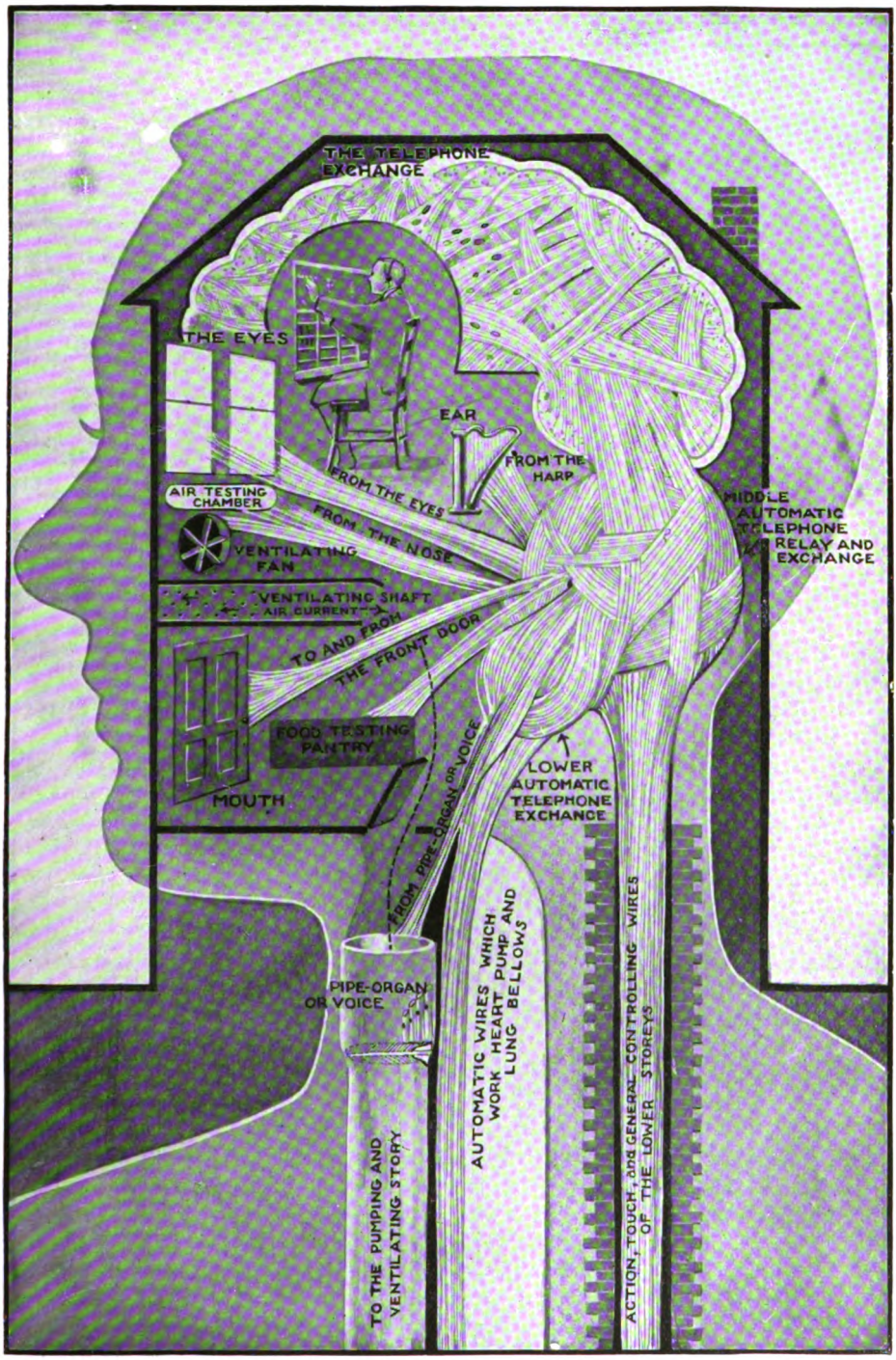
How important it is to know how to keep in perfect order the many rooms of this marvelously constructed house of ours; what guests to invite there and against whom every door should be closed. All success and happiness of life, even the house itself, may be wrecked by a single act of ignorance or neglect. The Book of Our Own Life tells the story of the things we should know about ourselves—how we should live in the house not built with hands.

BLOOD CIRCULATION IN THE HUMAN HOUSE

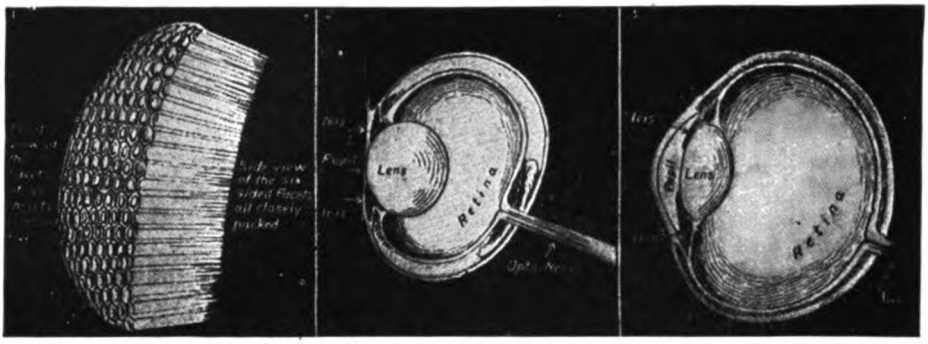


This picture shows the wonderful pump, called the heart, in the middle of the human house, and we can see here also how the ovens and corridors are linked up with the top story. The heart pumps blood through the body, and if we start at the right ventricle, and follow the arrows, we can trace the course of a drop of blood through the body back to the heart.

BRAIN SIGNALS OF THE HUMAN HOUSE



The study at the top of the wonderful house which builds itself, and from this room run the telephone and telegraphs by which we control all our affairs.



The first picture shows the eye of a fly, the second that of a fish, and the third that of a man, and we can see, by comparing these, how much nearer the fish's eye is to a man's than is that of an insect.

STORY OF THE EYE

THE sense which we are now going to study is vision, or seeing, and the organ of this great sense, as everyone knows, is the eye. In many ways, this is the most wonderful and important of the senses. It is so for the purposes of practical living. It is more necessary to see than to hear, or taste, or smell. A blind man is at a greater disadvantage than a deaf man. The progress and ascent of living creatures on the earth have very largely depended upon vision, and we have already learned that the vision part of the brain is largest in the highest forms of life. It is much larger in ourselves than in any other creature.

Vision is also of the highest importance for our ideas of the world in which we live, just as it is for our practical doings in that world. If we could not see we should know very much less of our own earth, and we should know the sun only by the radiant heat that it sends us; and all the other heavenly bodies would be unknown to us—from our own little moon to the millions of stars. It is upon our eyes, then, that our knowledge of the great world beyond our own earth depends, and on this claim alone our eyes are entitled to special respect. Unlike any of our other senses, they put us directly in touch with the infinite and the sublime.

One of the greatest men who ever lived, said that there were two things which filled him with awe—the feeling of duty inside the minds of men and the starry heavens above us. Let us begin, then, by studying how, in the course of long ages, living creatures have been able to develop the eyes by which the starry heavens are seen.

This question of the history of the eye is deeply interesting. A short time ago we should have begun at once with the history of the eye in the animal world. It would not have occurred to anyone that there was anything to say about eyes or seeing in the world of plants, but it has just been discovered that seeing, of a kind, at any rate, is not confined to the animal world. There are older eyes than any backboned animal, at any rate, can boast of, and we find them among plants. If we are really to understand our own eyes, therefore, we must begin at the beginning, with something much older and simpler than our eyes or any part of us.

The eyes of plants are very simple. The business of a green plant, and especially of the leaf of such a plant, is to receive and use the light that falls upon it. It is therefore in the

leaves of plants that we find their eyes. Simple experiments—which have now been made many times over, with many kinds of plants—show, to begin with, that somehow or other the leaf gets to know about the light.

For instance, if the direction of the light is altered, in a very short time the leaf turns itself, so as to get the light fair and square upon its surface; and some leaves will do this as often as the direction of the light is changed. We may, perhaps, get rather wrong ideas if we say that the leaf sees the light, yet that must be what happens; only it is a very simple kind of seeing.

The little eyes by which a leaf can see

After it had been completely proved that somehow or other the leaves can see, the next thing, of course, was to find whether the leaf saw as a whole, or whether it had any special places where it saw—places which must be called eyes of a kind. When the surfaces of leaves were carefully examined, it was often found that there were places where there was developed a kind of simple eye. That is to say, certain of the cells forming the surface of the leaf were made of a special shape; it was found that the outside of these cells is curved, just as the front of our eyes is curved.

The consequence is that light falling upon these cells is focused, as we say, and thrown upon the floor of the cell, just as a curved piece of glass will focus the sun's rays and throw a bright spot on a piece of paper. If the leaf is at right angles to the light, then the bright spot made in this way will fall right on the middle of the floor of the cell.

What Happens When a Leaf Does Not Look Straight At The Light

This corresponds to what happens in our eyes when we are looking straight at a thing, and the picture of that thing falls, as we shall soon learn, upon exactly the right place at the back of our eyes—the place where we see best. But—when the leaf is not facing the light—not looking straight at it, as we might say—the little bright circle that should fall upon the middle of the floor of the cells is thrown somewhere to one side of the floor, or may even be thrown not upon the floor of the cell at all, but upon one of its walls; and the life of the cell knows the difference.

Of course, these discoveries have excited the greatest interest, and at first many doubts were expressed, but these have all been cleared away. In the first place, it was necessary to prove that the curving of the surface of the cells really made them act like little lenses.

In two ways this can be proved; either the surface of the leaf can be shaved down, so that it becomes flat, or else a little water can be laid on the leaf and then covered with a thin sheet of glass, in such a way that the water fills up the hollows between the cells, and so makes the leaf flat, whereas before it was covered with hundreds of little bulging eyes.

When these experiments were made, it was found that the plant no longer responded to the light; the leaf no longer turned so as to face the light directly—in a word, it no longer knew where the light came from. Its sight had been spoiled just as our sight would be spoiled if something of the kind were done to our eyes.

Photographs That Can Be Taken With The Eyes Of A Leaf

And then, still more lately, the power of these little eyes was proved in another way. If these cells with their curved fronts really act as lenses, then, with care and skill, it ought to be possible to make them take photo-

graphs—that is to say, it ought to be possible to use these little cells as the lenses of a hundred tiny little cameras. This has been done, and the most excellent photographs have been taken —photographs so good that the person photographed can quite easily be recognized when the photograph is magnified and thrown on a screen.

This subject is quite new, and we are only at the beginning of our knowledge of it. A beginning has been made, however, with a new chapter in our knowledge of plants and their wonderful lives. Here, it is sufficient just for us to know that plants, which live by the light of the sun, and upon whose life our own lives depend, have little eyes of their own, which they use for their lives, and therefore, in the long run, for ours. It is because all animal life depends upon plants that we should know these things. And now we can go on and study the history of the eye in the animal world.

In the very lowest forms of animal life we find that there is response to light, for we find that some of the simplest kinds of animals will always travel from shadow into the light, and others will always travel from light into shadow. These are creatures whose bodies are so simple that we should not look for any special organ of vision.

How the first trace of an eye is found in the skin

Probably the first trace we have of such an organ—that is to say, the first trace of an eye—is where we find that, in certain lowly animals, parts of the skin are very sensitive to light. We find in such cases that the color of the animal changes according to whether it is in light or in darkness or in shadow, and when its skin is examined under the microscope, we find that it contains a large number of cells packed with colored material.

This is usually called pigment, which is simply the Latin for paint—in fact, another form of the word paint. These pigment-cells are sensitive to light. When light shines on them, all the pigment is gathered tightly up into the body of the cell; but when the light is taken away, and they are in shadow, the pigment strays out in all directions from the center of the cell, and so is scattered.

This explains why the color of the animal changes, and it also tells us why and how the animal is able to know what the state of the light is, and to act as it pleases accordingly. In the study of the history of the eye, great stress has always been laid upon these pigment-cells; but now that we have discovered such wonderful eyes in leaves, fitted with lenses so perfect that they will take photographs, the pigment-cell, which we look upon as the beginning of the animal eye, seems to be a very poor affair compared with a plant eye.

The little cells in the skin upon which light acts

We do not know exactly how it is that light affects the pigment-cells, but we may be sure that the action is really a chemical one. Everyone who is interested at all in photography knows that light has a chemical action —as, for instance, on the salts spread on a photographic plate. Every housewife whose curtains fade, or who puts clothes out to be bleached, knows also that light has a chemical action. Its action on the pigment-cells is chemical also; and when we come to study what happens in our own eyes when the light strikes the curtain at the back of them, we shall find that what happens there is very like the action of light when it takes the color out of a curtain or a gown.

What happens next in the history of the eye is that the pigment-cells

which were at first scattered about the surface of the body, get to be specially collected in certain places. These cells are not quite on the surface of the skin, but are underneath the outer skin, and the next stage is that, at the place where the pigment-cells are gathered together, the outer skin, or epidermis, becomes thickened, and bulges a little. Now, this is very important, because if we have a bulging or a curved surface, through which the light must pass on its way to the pigment-cells, we have indeed a lens of the shape called *convex*, and, as we know in the case of the burning-glass or the lenses of leaves, the result is that the light is focused.

THE SIMPLEST KIND OF EYE, AND THE WONDERFUL EYE OF A FLY

Now, we have already learned enough to be sure that these pigment-cells, like every other part of the body, are connected by nerves with the brain. So now we have reached the stage where there is a lens to focus the light, sensitive cells to be chemically affected when the light falls upon them, and nerves that somehow convey a record of these changes to the brain, which therefore sees. Here, then, is a simple kind of eye, complete from the surface to the center.

All the eyes of animals that have no backbone are to be looked upon as simply improved patterns of this kind. The eye in such creatures is always developed from the skin in the case of each individual, just as we have learned that, in the history of these animal forms, the eye has gradually become developed from the skin. We shall soon see that the eyes of backboned animals are of a much higher type; but we must not underrate all the eyes below backboned animals, because it is very certain that the eyes of some insects are exceedingly keen. It is generally agreed that the dragon-fly is the most wonderful insect of all in this respect. Its eyes are extremely large and powerful.

As in many other cases, the lens of the eye, instead of being just curved in one single simple bulge, is like a large diamond that has had its face cut into a number of little flat surfaces. These little faces of the lens are usually called facets. The number of facets upon the lens of the eye of the dragon-fly is very large.

HOW THE DRAGON-FLY AMUSES ITSELF BY AMUSING MEN

Few things are more wonderful than the certainty and skill with which the dragon-fly will recognize, follow, and catch the smallest insect on the wing. One of the greatest living students of this subject, Professor Forel, one of the many wise men who have made Switzerland famous, writes as follows: "By trying to catch them at the edge of a large pond, one can easily convince oneself that dragon-flies amuse themselves by making sport of the hunter; they will always allow one to approach just near enough to miss catching them.

"It can be seen to what degree they are able to measure the distance and reach of their enemy. It is an absolute fact that dragon-flies—unless it is cold or in the evening—always manage to fly at just that distance at which the student cannot touch them; and they see perfectly well whether one is armed with a net or has nothing but his hands. One might even say that they measure the length of the handle of the net, for the possession of a long handle is no advantage. They fly just out of reach of one's instrument, whatever trouble one may give oneself by hiding it from them and suddenly lunging as they fly off."

We must not suppose that all insects have good eyes; there are all

stages between the dragon-fly, at one extreme, and insects which are completely blind, as, for instance, the cave-dwelling insects and certain kinds of worker-ants which live entirely underground.

THE HOUSE-FLY THAT HAS LEARNED TO KEEP AWAY FROM THE GAS-FLAME

The rule for most insects is that they fly towards the light. Artificial lights, such as we use, do not occur in Nature, and an insect flying towards a lamp really supposes that it is flying towards the light of day. It is most unfortunate, from our point of view, that a good many domestic insects have learned in the course of many years to know what artificial light is. We cannot now enter into the very difficult question how it is that this change has been brought about in their natural habits; but, at any rate, it is the case that such an insect as the ordinary fly does not destroy itself by flying against a flame.

The habits of flies are extremely dirty; their feet are always laden with filth. They are thus great carriers of disease, and destroy many babies every year by poisoning their food. That is why it is very unfortunate that flies have learned how to behave to artificial light in what, for their ancestors, would have been an unnatural way.

Many years ago Lord Avebury showed that bees and wasps were able to distinguish colors; but wasps are very inferior to bees in this respect. Bees distinguish all colors, and very rarely make any mistake except between blue and green. The importance of this is very great, because it largely helps to explain how it is that bees are able to distinguish one flower from another.

INSECTS THAT CAN SEE WHAT OUR EYES CANNOT SEE

As a rule, the color of a flower is a kind of flag held out to say to a bee or other insect: "Come here; I have something that you will like." So the bee gets its honey and the flower gets fertilized. Thus we owe the pleasure our eyes get from most of the beautiful flowers we know to the fact that the eyes of bees and other insects are able to see them and to distinguish them. If there were no insects there would be no beautiful flowers; there would be nothing for the plant to hang out its flag for.

It was also proved by Lord Avebury, that ants, for instance, can see kinds of light to which our eyes are blind—that is to say, the light which lies beyond the violet, and which is known as *ultra-violet* light.

Here we may notice, what has recently been shown, that people's eyes vary in this respect. Just as old people do not hear high-pitched sounds, which younger people can hear, so we find that there are a good many young people who, somewhat like ants, can see a little way, so to speak, into the ultra-violet, where, to the rest of us, it is quite dark. Finally, Lord Avebury has shown that ants are able to recognize each other after more than a year of separation. Let us beware of judging the value and power of things by their size, and let us learn from this brief account of one of the senses of insects that we still have reason to go to the ant to "consider her ways and be wise."

Now we must pass to the eyes of backboned animals. The lowest kinds of backboned animals are the fishes, and we have all seen the eyes of fishes. Wonderful and skilful as the eyes of insects may be, the eyes of backboned animals are of a vastly finer and more wonderful type. In the first place, this seems to depend upon a change in the making of the eye. We have seen that the eyes of all the animals that

have not backbones are entirely formed from the skin; but the higher type of eye found in backboned animals has its most important parts developed from the brain, and not from the skin at all.

True, the front part of such eyes as our own is formed from the skin, but that is only true of the parts through which the light travels on its way to the all-important curtain which makes the back of the eye. That curtain is really a part of the brain which has been pushed out, as it were, from the brain upon a kind of stalk or stem.

The real reason why the curtain, or retina, of the eye of backboned animals has its great powers—vastly superior to those of any lower type of eye—is that this retina is, indeed, a part of the brain itself. Vision is so important that the business of receiving light-rays could not be left to anything developed from the skin; so a portion of the brain itself extends forward to form a portion of the eye and especially the retina.

In main principles, the eye of backboned animals is much the same, no matter which particular animal we take. The eye of the fish is certainly very much inferior to that of a bird or a mammal, as we should expect, if we consider that the fish has to see only in water, where it would be impossible for any kind of eye to see more than very short distances; but even the eye of the fish is, in all the main points, the same as our own, though much simpler.

We need not discuss specially the eyes of birds, though everyone knows that they have some powers superior to those of the eyes of any other creature. These powers are in the direction of keenness, so that we say of anyone who is very sharp to see things that he has the eyes of a hawk. This keenness is at its best in the case of the hawk and other birds of prey, but other birds also have very keen eyes. They could not catch flying insects if they had not. In praising the eye and the keenness of vision in birds, and in studying their eyes, we must not make the mistake, which is commonly made by almost everyone who has studied this subject and written upon it, of supposing that mere keenness of vision is everything.

It is easy to see what a mistake that is, if we consider the case of a sailor, for instance, who has very keen eyes indeed, and can see far into a fog, but who would perhaps never cast a second glance upon the most noble picture that was ever painted, or upon the most lovely landscape. On the other hand, a great artist may be old and very nearly blind, and though his vision is very dim, yet he can see in a sunset or in a picture things which mere keenness of vision, whether in a man or a hawk, could never see at all. This is worth remembering, for it is just as true of all the other senses as it is of vision.

Keenness is not the highest quality of a sense, and the best proof of the rightness of our view is to be found in the fact that, when we test the matter by the brain, we find that the vision area is largest and most highly developed, not in the insect or the bird, or in the men with the keenest eyes, but in the brains of the highest type of men, who have learned to see and love what is beautiful and poetic.

THE EYELID THAT WASHES THE EYEBALL AND KEEPS IT MOIST

And now we are prepared to look at our own eyes and see how they are made. It is proper to mention the eyelids, because they exist for the sake of the eyes, and the eye cannot get on without them. We are very wrong if we suppose that the eyelids

merely exist in order to cut off the light when we do not wish to see. They have that purpose, but if we had to do without them, and replace them by an artificial shade, we should soon find that that is not the whole of their use, but that they have another use that is of the greatest service to the eyes.

Every time that we wink—which we do every few seconds without thinking about it—the upper eyelid washes the front of the eyeball by means of a tear which has come from the tear-gland, and has been spread over the inside of the upper eyelid.

The left eye, showing the glands where the tears are made and the ducts through which they are carried to the nose after washing the eyeball. In weeping, the tears cannot all pass through the ducts, and so they overflow.

The tear-gland lies above the eyeball, a little to its outer side. The tear, after washing and moistening the front of the eyeball, passes through a tiny hole at the inner end of the lower eyelid into the nose.

WHY WE CRY WHEN WE ARE IN SORROW OR DISTRESS

The reason why we cry when we are distressed seems at first to be that the part of the brain connected with the tear-glands lies very close to the part of the brain which is disturbed when we are made unhappy.

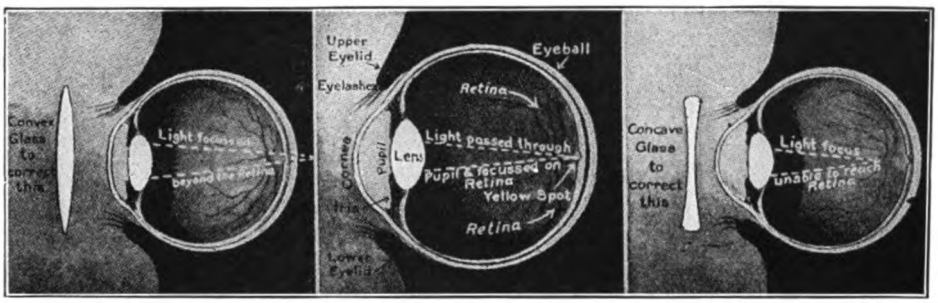
The real reason, we may believe, why we show signs of distress in our eyes rather than anywhere else is that we human beings live by one another's help and sympathy and love. We are meant to see when others are unhappy, so that we may know, beyond any doubt, when they are needing our sympathy and help.

If a child's mouth merely watered when it was unhappy, we should not know, and therefore would not help it; but when we see its eyes water our sympathy is aroused, and we help it. We cry, not because the brain happens to be so made, but the brain has been so made because crying is the most useful and convenient way in which our distress can be shown to others.

HOW THE FACE AND THE EYE EXPRESS OUR FEELINGS

As the higher parts of the brain develop we learn self-control, and cry very much less readily than when we are quite young; but it is still true that our feelings find expression that can be seen by other people, for the face shows our feelings, and when we make a general study of the way in which our feelings are expressed by the various parts of the face, we shall see that crying fits in with these other ways of expression as the watering of the mouth would not, so that it is more than a mere chance that sorrow and sadness find expression in the shedding of tears rather than in the production of saliva or in some other way.

The eyelids are provided with hairs which help to protect the eyes from dust. Besides the protection afforded by the eyelashes, the eyebrows are to be reckoned with, as they prevent the sweat of the forehead from running into the eye. Lastly, we have to notice the well-contrived bony structure of the skull around the eye, which furnishes a very wonderful protection.



In the middle picture we see a section of a perfect eye, with the light focused correctly on the retina. The left-hand picture shows an eye in which the cornea is too flat, and the light being focused beyond the retina causes indistinct vision. The eye on the right hand has the cornea too convex.

PARTS OF THE EYE

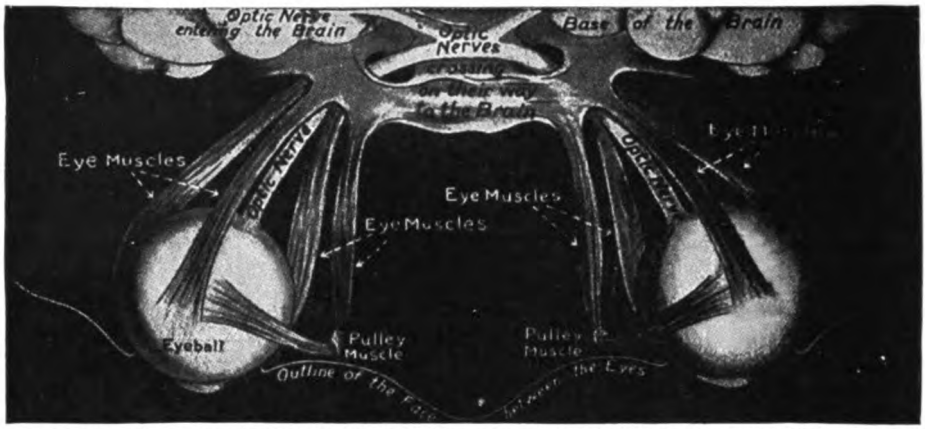
WHEN we examine the eye, the first thing we notice is that the front of it is transparent. This round, transparent part in front is called the cornea, which really means the horny thing. If we look very carefully at it, we shall see that it bulges forward somewhat. The curve of it is not quite the same as the general curve of the eyeball. This shape of the cornea is very important because of its effect on the rays of light that enter it. It acts just like the curved surface of the eye-cell of a leaf.

The first and greatest business of the cornea is to be perfectly transparent. It contains, therefore, no blood-vessels, small or great; it would not do to have red or white blood-cells in the cornea interfering with the passage of light. But the cornea is alive and must be fed, and it is supplied by materials that pass to it through the walls of the tiny blood-vessels that we find all around its edge. The cornea is well supplied with nerves, nearly all of which run to its front surface, in order that it shall be very sensitive.

This is necessary so that the least speck of dust or anything else that would injure it, shall be felt and wiped away by the eyelids and the tears. Only too often, however, a workman gets what he calls a "fire" in his eye, and then there is a great risk that, when the cornea recovers from the injury, the injured place will be opaque for the rest of his days. Also, when anything of this kind happens to the cornea, blood-vessels grow into it from the side. They must do so, for they must supply food and other materials to the injured part, if it is to recover; but these blood-vessels mean that the passage of light is interfered with.

Recently the first attempt that has ever succeeded was made to remove a piece of cornea that had become opaque, and to graft there a piece of healthy transparent cornea. It is well for us to understand how important and wonderful this part of the eye is. All the light we see by must pass through it; yet it is a living thing, with all the needs and delicacy of a living thing—very different from a curved piece of glass. Lastly, it is very much exposed, though, as we know, the eyelid, eyelashes, eyebrow, and the bony wall around the eye do their best to protect it.

All round its edge the cornea passes into the white, thick, strong coat of



This picture helps us to understand how the eyes grow out of the brain, the optic nerve projecting till it expands into the hollow cup of the eyeball. The muscles that move the eyes are also shown.

the eyeball; indeed, the cornea is really a special part of this strong outer coat of the eyeball that has been made transparent, and has been made to bulge forward a little in order to help in focusing the light. The white outer coat of the eyeball is very strong, and will stand a good deal of pressure. If we feel one of our own eyes with the finger, we shall find that it is quite tight; and the existence of this pressure in the eyeball, which is supported by the outer coat, is of great importance for good seeing.

Now, when we look at anyone's eye, we see something through the transparent cornea. We see a round, colored ring with a black hole, small or large, in the middle of it. The colored part is called the iris, and it is a ring of muscle with a hole in the middle of it, which is the pupil. This looks black because it is really the hole leading into the dark chamber, or inside of the eye, which is like the inside of a camera. Now, if we could be shown an eye cut through sideways, we should see that there is quite a large space between the cornea and the front of the iris. This space is filled with a watery fluid, and the light has to pass through this fluid before it is able to reach the pupil.

THE PUPIL OF THE EYE THAT GETS BRIGHT IN A DIM LIGHT

The business of the iris is to regulate the size of the pupil. The less the amount of light, the larger must the pupil be; and the more the light, the smaller the pupil. So when a person goes from darkness into light, or when the eyes are opened in a bright light, anyone may see that the pupil gets smaller. We can also notice that the pupil gets smaller if a person who has been looking at something far away suddenly looks at something close to his eye. There is a special reason, rather difficult to explain, why it improves the clearness of vision to reduce the size of the pupil when looking at something near. The cause is to be found in the shape of what lies behind the pupil, as we shall soon see.

All the color of the eye is due to the iris. The color is not to be found at all in the muscle fibers that make the iris; they are just like other muscle fibers, and are the same in everybody. But both on the back and front of the iris there is a layer of cells, which may or may not contain a certain amount of pigment, or paint. It is this that varies in different people. It is interesting from the point of view of beauty, because its variations in dif-

ferent people provide many different types of beautiful eyes. But the color of the iris has quite lately become most interesting, because we are just beginning to learn what are the rules as to the way in which eye-color descends from parent to child. This is one of the subjects which is being closely studied by scientific men all over the world, and we are no doubt going to learn a great deal from it.

THE PEOPLE WITH BLUE EYES AND THE PEOPLE WITH BROWN EYES

It seems that some eyes have brown pigment in the cells on the front of the iris, and others have not. This gives us at once two great types of eyes—those which have the brown pigment on the front being more or less brown, and those which have not being more or less blue. There is far more to say than this, of course, because, as everyone knows, there are many different blues and browns, and many eyes which could not be called either. But still we have already learned that a father and mother with genuine blue eyes never have brown-eyed children; on the other hand, if one parent has brown eyes and the other parent has blue eyes, most of the children, at any rate, will have brown eyes.

At present in this country it seems quite plain that blue eyes are rapidly becoming rarer and brown eyes commoner. One of the deeply interesting questions is as to why this is so, and what the consequences will be. Careful study of the iris in thousands of people in all parts of the country, and especially the study of the eyes of children as compared with their parents, will teach us not only a great deal about heredity, as it is called, but will also help us to learn what is really happening, and how far it is true that the blue-eyed strain in our population is dying out and the brown-eyed people surviving.

THE PEOPLE WITH BLUE EYES WHO ARE DISAPPEARING FROM THE WORLD

It is very likely that though the blue-eyed seem less able to bear city life, and the conditions of existence nowadays, they may yet have many valuable qualities, and their slow disappearance threatens to be a great loss to the world, and ought to be thoroughly investigated, and some means found to check it.

Now, if we pass through the door in the iris, we find a beautiful transparent thing called the lens of the eye. It is a genuine lens, just like the lens of an ordinary magnifying glass, and it is of the same shape, convex on both sides. It helps to bend the rays of light entering the eye, just as the cornea did, and it is perfectly transparent. Unlike any lens that any man ever made, this lens, while able to do all that artificial lenses do, can do far more; for it is elastic, and can change its shape as we please.

HOW THE LENS OF THE EYE IS KEPT INSIDE A LITTLE BAG

The lens lies inside a little bag, and that bag has little fibers attached to it all round, which can be pulled upon by tiny slips of muscle inside the eye. When the bag is pulled upon in this way all round, the lens inside it is made flatter. When the muscles stop acting and the pulling ceases, the lens is free to bulge out again if it is perfectly elastic.

It is by this power of the lens that we are enabled to see clearly both at short distances and at long distances. Now, as everyone knows, in the case of an ordinary camera, it is equally necessary to focus the light properly if the picture to be taken is to be sharply defined on the plate; or if we are using a magic lantern, we know that we must focus properly if the picture is to be sharply thrown on the screen. In these cases, and in all

other cases where men use artificial lenses—as, for instance, in the microscope and the telescope—the same method of focusing is employed, and that is to alter the distance of the lens, or lenses—for there may be several—from the place where we want the image to fall.

How our eyes focus by changing the shape of their lenses

It is very interesting to discover that in the fishes this method, which men employ in all their instruments, is employed in the eye: the lens has its position shifted nearer to or farther from the retina, or screen, at the back of the eye. But in all the higher types of eye, such as our own, this method is not employed. There is no arrangement for shifting the lens backwards and forwards in order to suit the distance of the particular thing we are looking at. Its distance from the retina is fixed. The method of the higher types of eye is not to alter its position, but to change its shape where it stands. That is why it has to be most perfectly elastic, so that after it has been flattened, by having the bag in which it lies pulled upon, it can spring back perfectly to its rounder shape.

This means that the shape of the eyeball, as a whole, is very important. An eyeball may be long from back to front, and then the lens is far from the retina, or it may be short from back to front, and then the lens is nearer the retina. If the lens be of the same shape in the two cases, one eye or both must certainly not be quite suited to its purpose. Thus, in consequence of the varying shapes of eyeballs, the variations in the curve of the cornea, and the variations in the shape of the lens itself, we find that there are a very large number of people whose eyes are not perfectly suited for all kinds of use.

Near-sightedness has nothing to do with the health of the eye

Nothing is more important than for us to understand, at the very first, that this is not at all a question of the health of the eye. An eye may be healthy or ill, like any other part of the body, but what we are now talking about is simply a question of the mere shape of the eye or certain parts of it. The bending of rays of light is called refraction, and so we usually speak of "errors of refraction" to describe those cases where an eye is near-sighted or far-sighted, or has some defect of that kind.

This has nothing to do with the health of the eye or of any other part of the body, except that, as we shall see, if something is not done, the rest of the body may be affected. We are to look upon the eye for the moment as a kind of optical instrument or machine, and simply to realize that the shape of this optical instrument will affect the rays of light that pass through it, just as in the case of any other optical instrument.

It is very commonly found that the cornea is not quite regularly curved; it bulges more or less in one direction, say, from side to side, than it does in another direction, say, from top to bottom. This means that, if we are looking at a cross, the one limb of it cannot be seen sharply if the other is. As a rule, this defect in the shape of the cornea is so slight that it is not worth bothering about; but often it is worth while to wear glasses which are more curved in one direction than in another—more curved in the direction in which the cornea is less curved, and less curved where the cornea is more curved—so that the little defect is corrected. This particular error of refraction is not nearly so important as those we must now study.

Near-sightedness is what happens when the eyeball is rather too long from back to front. This error of refraction means that the light is focused before it reaches the retina, and when it does reach the retina the picture it makes is rather blurred. Sometimes, also, near-sightedness may be due to the cornea being too much curved, so that it acts as too strong a lens, and the rays of light are focused too soon.

WHY IT IS THAT SOME PEOPLE BECOME NEAR-SIGHTED

Near-sightedness is a very common defect, and is very inconvenient. We can see anything near quite well; the things farther off are blurred. The reason why we see things clearly when they are quite near, and why we therefore always hold a book close to our eyes, is that, when a thing is held close, the image of the object is larger, and so more easily seen.

People who start near-sighted when they are quite young, or who even are far-sighted at first—as most young children are—often become gradually more and more near-sighted until the age of, perhaps, thirty. Most of the people who study this subject are very sure what the cause of this is, only, unfortunately, they do not agree with each other.

Some of them who have not really gone into it properly think that the near-sightedness is a sort of disease of the eye, and is due to over-use of it, bad conditions during childhood, and so forth. Others think that it is a natural change which is bound to happen in any case; and still other people suppose that this increase in near-sightedness is due to the constant use of the eye at short distances.

The truth lies somewhere between the last two opinions; each of them is probably true in part. The eye, like other parts of the body, does undergo natural changes during life, and as it gradually becomes more far-sighted after a certain age, quite apart from anything that is done to it, there is no reason why it may not become more near-sighted during the earlier years.

HOW NEAR-SIGHT IS CAUSED BY USING THE EYE FOR SHORT DISTANCES

On the other hand, we can prove that, when the eye is used for short distances, certain muscles inside it are used in such a way as to tend to make the eyeball longer from back to front, and therefore more near-sighted.

The reason for going carefully into this is that very few people understand the facts, and many doctors even have not properly inquired into them. Young people between the ages of twenty and twenty-five find, very often, that year by year they get rather more near-sighted; perhaps they require to use glasses where formerly they did not need them, and the glasses have to be made stronger or parents find their children require glasses for near-sight.

People are alarmed if they think that all this means a kind of disease of the eye, or if they begin to ask themselves where this is going to stop. That is why everyone should understand that near-sight is not a disease at all; that the changes which go on are natural; that they only go on to a certain point.

More than this, it is certain that we may look upon near-sightedness in our time as a kind of adaptation to our needs—that is to say, in the case of the great majority of people who have to use their eyes at short distances. For such distances the near-sighted eye is just the best that one can have; it lasts splendidly, and does not tire.

NEAR-SIGHTED PEOPLE MAY BECOME FAR-SIGHTED AS THEY GROW OLD

After a certain age, perhaps about forty-five, or later, the eyes, after

having remained just as they were for many years, begin slowly to become far-sighted, or less near-sighted, as the case may be. But before we look at this we must return to the case of the child.

Practically all very young children are far-sighted. A certain number of them remain far-sighted as the years go on, and are still far-sighted when they begin to learn to read and write. There is no more disease or ill-health here than there is in the other case, but simply the eyeball is too short from back to front, the cornea is too flat, and so the rays of light are not focused sharply in time, and reach the retina sooner than they should. The retina is too near the lens.

Now, in days that are gone this was no serious matter, because people lived far more natural lives than they do now. They lived much more in the open air. Instead of constantly reading books at a few inches distance, they had to read the book of the distant clouds and mountains; they had to see animals or enemies at great distances, and the use of their eyes for short distances was only occasional.

THE DIFFERENT USES FOR WHICH NATURE HAS FITTED DIFFERENT EYES

When the eye is to be used at long distances, evidently the far-sighted eye has little of which to complain.

But the far-sighted eye is too short from back to front. The rays of light are not focused in time. Now, if such an eye is to be used at short distances, it will be very much strained, because the muscles inside the eye will constantly be trying to change the shape of the lens in order to make the eye focus better; in fact, the far-sighted eye requires to use the muscles inside it in all circumstances. This means that it is liable to get tired, and every far-sighted person knows what it is to get headache and eye-strain from the use of the eyes under conditions which would not be at all inconvenient or disturbing to a near-sighted person.

THE FOOLISHNESS OF MAKING CHILDREN USE THEIR EYES IN A WRONG WAY

In our ignorance and carelessness regarding children, we at present inflict very grave cruelty, and perhaps often injury that is never recovered from, upon large numbers of children everywhere by compelling them to use far-sighted eyes for purposes to which they are not suited.

All over the country, children are straining their eyes at reading and writing, gaining no good, but only harm, from what we do for them, and all they need is a pair of spectacles with rounded convex lenses that will help to focus the rays of light quickly, so that they are brought sharply together by the time they reach the retina at the back of these short eyes. It is the short eye, we must notice, that is far-sighted, and it is the long eye that is near-sighted.

It is just beginning to be discovered how important this subject is, and, now that it is slowly occurring to us that before we start educating a child we must make it fit to be schooled, we may hope that, within a few years from now, no far-sighted child will be allowed to be injured for the lack of spectacles. The relief obtained when proper glasses are employed is quite astonishing.

As we shall readily understand, it is concave lenses that are used in spectacles for the near-sighted eye, and convex lenses that are used in spectacles for the far-sighted eye. We may think this out for ourselves.

As people become elderly, the eye becomes more far-sighted; this change oftenest occurs at some time after forty-five. If the person was near-sighted, he now becomes less so

Indeed, if we take the whole course of life, there can be no doubt that, under ordinary modern conditions, the near-sighted person is much better off than the far-sighted person, although at first it may not appear to be the case.

THE LENS OF THE EYE THAT CEASES TO BE ELASTIC AND CAUSES FAR SIGHT

The far-sightedness of elderly people is due to changes that occur mainly in the lens of the eye. The all-important elasticity of the lens becomes impaired, and it does not bulge, when the pressure of its coat is removed, as readily as it used to do; indeed, it becomes decidedly flatter. In extreme old age the lens loses its elasticity to such an extent that its shape cannot be changed at all.

The commonest sign that the eyes are beginning to show this change is that the person finds it more difficult to read in a dim light. It is very much better to be sensible about this and wear glasses than to try to fight against it. This does no good, and, on the other hand, it may do just the same kind of harm as is done to the far-sighted child that is "educated," as we call it, without having glasses provided for him. The same is true in this case, as has been seen, that people suppose the need for glasses to be a sign of weakness or disease, and think they ought to fight against it.

Now, it is good to fight against weaknesses, and there is not much hope for people who do not; but the weakness is in being too proud to wear glasses or too careless.

WHY MANY GREAT MEN OF THE PAST BECAME BLIND

In old age, or sometimes before it, the lens of the eye may become opaque. Much the commonest form of this misfortune is found in old age, but there is also a very definite form which may occur in quite young people, and which is known to appear in a regular way in parents and children. Cataract is the name applied to opaqueness of the lens. Its consequence is blindness. The time was, and that quite recently, when there was no remedy for this terrible affliction.

We know that many of the very great men of the past became blind in their old age, and in many cases it was cataract that was the cause. Nowadays science triumphs over this calamity. Thanks to those who have studied the structure of the eye, and thanks to Pasteur and Lister, who have taught us how to keep microbes away from wounds, so that they shall heal easily and painlessly and certainly, it is now possible simply to make a little cut in the eye, then a little cut in the coat of the lens, and then, by a little squeeze, to push the lens out through the cut which was made—and there it lies in the surgeon's hand, looking almost like a little lens of ground glass.

This would probably have to be done to both eyes, though it makes all the difference in the world if it were done to only one eye when both were affected. It is easily done, without pain. The obstacle to the light is now gone, and the light can pour through to the retina; but the rays are not focused, and things cannot be properly seen.

HOW SCIENCE IS ABLE TO GIVE SIGHT TO THE BLIND

The remedy is to supply the person with spectacles, with strong convex lenses that take the place of the lenses he has lost. Few operations, so simple and so easy and so certain, do so much for old people, and it would be worth while to study the eye, if only to learn how it is possible, by the application of our knowledge, to give sight to the blind in this way, as is done all over the civilized world many times daily.

In the first picture we see a section of the eyeball between the blind spot and the optic nerve. The middle picture shows the interior of the eyeball with the nerve fibers radiating from the blind spot. In the right hand picture a portion of the retina is highly magnified showing the various layers and the rods and cones.

SEEING COLORS

IN some ways, the most wonderful of all the feats that the eye performs is the seeing of colors, and this subject of color vision, as it is usually called, is also very important from the practical point of view, because in many cases we require to distinguish one color from another; and sometimes the lives of many people may depend upon the certainty with which this is done.

We know that light is a wave motion in the ether. A better way of putting it would be that there are wave motions in the ether which, when they fall upon an eye, give rise to light. Apart from eyes to see, all Nature is in darkness. Neither the eye nor the ether alone can make light, but both are required. We can count the number of vibrations of the ether that affect the eye in a single second.

The smallest number per second that we can see is roughly about four hundred billions. When we see these we get an impression of red. The highest number we can see is roughly about eight hundred billions, and when such vibrations affect our eyes we see a sort of violet.

Now in music a note that is an octave higher than another has exactly twice the number of vibrations in a second; and so we may say that the amount of light that our eyes can see corresponds to one octave, the number of vibrations of the violet being about twice the number of the red. We must clearly remind ourselves once more that just as there are sounds higher and lower in pitch than the eleven octaves or so which we can hear, so there are ether vibrations higher and lower in pitch than the one octave or so that we can see.

We know that our distinguishing of colors depends upon the cones in the retina. We are bound to suppose that in those kinds of eyes where there are only rods, colors cannot be distinguished as they are seen by us; and we begin to understand the immense advantage of having a place in our eyes which is the most sensitive of all, and contains only cones.

From all this it follows that we do not see the colors of objects whose light falls upon the outermost parts of the retina, where there are no cones, or practically none. Also our eyes vary in sensitiveness at different parts of the color scale. At the actual extremes, such as red and blue, we do not notice slight differences in color so sharply as we do in between the

extremes, as in the yellow and green.

Colors vary in several ways. For instance, they vary in brightness, as we all know. The brightness of a color depends simply upon the extent to which it excites the brain. We cannot say why one color, because it is that color, should affect the brain more than another; but it is so.

Secondly, we find that colors vary in their hue, or tint, and that depends on the number of vibrations in each second of the ether waves which cause the color.

Thirdly, colors vary very much in what is called purity, or richness. The best types of eyes are very keen to appreciate this quality in colors. A pure color is one which depends upon light of one rate of vibration. The purity of a color is destroyed when it is mixed with other colors, or when it is mixed with white light, which really comes to the same thing, as white light contains all the colors.

THE MYRIADS OF COLORS THAT WE CANNOT SEE AT ALL

Now, quite apart from any question of the eyes, the question of color is simple, because it is exactly the same as the question of the pitch of sounds. Ten vibrations a second means one sound, eleven means another, twelve another, and so on. In the same way, between light made of waves running four hundred billions to the second and light made up of waves running eight hundred billions to the second there is really an infinite number of colors—hundreds of billions of colors. That is all very well, but when it comes to our seeing them we find that the case is different.

If we take white light and pass it through a prism, we get a band of colors called the spectrum, and when we look at it we quite clearly get the impression not of a regular even change of color from one end to the other, but of comparatively few colors to which we give definite names. Of these various colors, which are commonly described as seven, some give us the impression of being mixed, and others of being pure. For instance, what we call orange is mixed; what we are really seeing is a red and a yellow together. Then, again, Prussian blue is not a pure blue, but a mixture of blue and green.

THE THREE PURE COLORS THAT ARE NOT MADE UP OF OTHER COLORS

Now contrast with these colors such a color as crimson red. Nothing will persuade us that that is a mixture of other colors; it is simply red itself. There is also a tone of green which we cannot imagine to be made up of anything else, and the same is true of ultra-marine blue. Probably these are the only three colors of which this can be said. We therefore call red, green, and blue primary colors. The meaning of this is almost always misunderstood.

When we call red, green, and blue primary colors, we are not saying anything about light; we are talking about the way in which the eye sees. Light consists of waves of every rate of vibration, and any one of these rates is as good as another. But the eye, instead of being able to see each of these, has only got within itself means for seeing three of them directly, and these three are red, green and blue.

All the other colors it sees by mixing in various proportions these three kinds of sensation, and that is why we call red, green, and blue primary colors. By mixing these in various ways we can obtain the impression upon the eye of every kind of color that it can see. By mixing red and green rays in various proportions we can get the effect of all the scarlets, oranges, yellows, and yellow-greens; by mixing red and blue rays we can

get all the various violets and purples; and by mixing the green and blue rays we can obtain all the various shades of blue-green.

To the three primary colors we have to add a fourth—the gray color which we get from the rods of the retina.

A POWER THAT NO MAN UNDERSTANDS, BY WHICH WE SEE DIFFERENT COLORS AND SHADES OF COLOR

Of course, we now want to know what are the things in the eye which correspond to these various kinds of color sensation or color vision. This can be clearly answered as regards the gray color, for we know that that is due to the rods. We know also that the cones are responsible for the other three kinds of color sensation; but, unfortunately, we can go no further than this, except by guessing. For instance, we do not find that there are three different sorts of cones, nor do we find, as some have supposed, that there are three different parts to each cone—one for each kind of color.

Nor can we show that there are three different kinds of nerves running from the retina to the brain, as Dr. Young supposed a century ago. It may, indeed, be that we are altogether mistaken in looking at the retina for the key to the fact that we see colors by these three sensations.

It may be that the key to the facts is to be found not in the retina at all, but in the gray matter of the vision part of the brain. The fact that a man may be color-blind in one eye is rather against this.

As a rule, color-blindness occurs in both eyes, but there are cases where it is found in one eye only, and that, of course, suggests that it is the eye rather than the brain that is responsible for color vision. Color-blindness is almost always a state of things which exists from birth, and there is no cure for it.

PEOPLE WHO CANNOT SEE COLOR PICTURES

About four men out of a hundred, it is said, have one form or other of color-blindness, and about one woman in a hundred. This is by no means the only case in which peculiarities are found more commonly in men than in women. Color-blindness is passed on from parents to children, and we have lately gone far to understand the laws by which it is inherited.

Very rarely we find people who are quite color-blind. The spectrum of sunlight to them appears in shades of gray throughout, being lightest in the position of yellow-green, and darkest at each end. A colored picture to them looks like a photograph or an engraving. If we believe that our three color sensations depend on the presence of three special chemical substances in the retina, then we must suppose that in such cases all these three substances are absent.

Very rare also is "blue-blindness," in which the possibility of blue sensation is absent. Then there is "green-blindness," common, and very important, in which we suppose that the substance corresponding to the green sensation is absent; in such cases bright green is confused with dark red, and a dark green letter on a black background is not seen at all. If we remember that everywhere on railways red is used as the color of danger, while green allows the train to go on, we shall understand how very serious it would be if a railway signalman could not distinguish between a bright green color and a dark red color.

WHY RAILWAY SIGNALS ARE ALWAYS RED, GREEN, AND WHITE

Lastly, there is "red-blindness," also common, which is sometimes called Daltonism, because it was this that Dalton suffered from. Here we suppose that the chemical substance

affected by light and corresponding to red sensation is absent from the retina. In these cases light red is confused with dark green, and a dark red letter on a black background is not recognized at all.

Now, as nearly all color-blind men are either red-blind or green-blind, it was suggested that signal colors, instead of being red, green, and white, should be changed; for instance, blue and yellow might be employed. But this does not do. The only convenient colors to use for this purpose are red, green, and white.

It is found that a red glass allows about ten per cent of the light behind it to come through, and a green glass rather more, but a blue glass allows only about four per cent of the light to come through; and yellow does not do, for there are states of the light in which yellow would not be noticed.

It is necessary, then, to test people who are to be expected to recognize lights, and if they are color-blind they must find some other employment.

THE BEST WAY OF FINDING OUT IF WE ARE COLOR-BLIND

Scores of different methods have been invented for detecting color-blindness. The best method, which is generally employed, is the use of colored worsteds, and the person who is being tested is asked to match them. If a green-blind man is handed a skein of pale green worsted, and if he draws from the heap some worsteds which contain no green at all, then he must not be passed; or if a man takes a dark green as a match to a dark red skein, he proves himself to be red-blind, and must therefore be rejected.

HOW WE CAN REST OUR EYES BY LOOKING AT THINGS A LONG WAY OFF

Enough has already been said about spectacles and their importance in correcting the errors of refraction. Here we must note a few points which will help to preserve our eyes, quite apart from the use of spectacles.

When the muscles inside the normal eye are at rest, the shape of the lens and other parts is such that the eye is fitted to see distant objects. There can be no doubt that the first and most natural uses of the eye are for distant and not for near vision. The course of our lives is now such that we use our eyes very much at short distances, and this means the use of the muscles inside them. That is especially true of far-sighted persons, who should, of course, not use their eyes at short distances without glasses. But, apart from that, it is a good rule for all of us to relax our eyes, when we can, by letting them rest upon something which is distant, and so giving the muscles inside them a rest, and lessening the risk of strain.

The best light for vision is daylight —not direct sunlight, but diffused daylight reflected from the sky. When we use artificial light, which we do more and more, it is a safe rule that the nearer it resembles diffused daylight, the better it will be. When we call daylight diffused, what we mean is that it comes from a large surface—the general surface of the sky. What we call a soft light is always one that is diffused in this way.

THE BEST WAY TO LIGHT OUR HOUSES AND TO PAPER OUR ROOMS

In modern buildings the lights themselves should be entirely hidden, and we should see by light reflected from wall or ceiling. Of course, this is expensive, because more light is required; but, though it costs more money, it saves our eyes very much.

Another great fact about diffused daylight is that it is steady, and so should artificial light be. In this respect gas is a great improvement upon candles, and electric light is the best of all.

It has lately been shown by some French students that the different qualities of light affect our eyes in different ways, quite apart from their brightness. The safe rule is that we should, as far as possible, make our artificial light of the same composition as sunlight.

In our houses, if we are wise, we shall have spaces upon which the eyes can rest. This means that we shall think twice before we use wallpapers with marked patterns; this is true especially of bedrooms, because, sooner or later, someone is likely to lie ill in a bedroom, and, whatever healthy people can stand, wallpapers with patterns are a distress and a nightmare to sick people.

THE SAFE RULE FOR READING BY DAY AND NIGHT

Great stretches of Nature are green. There is probably no color which fatigues the eye less in proportion to its brightness than the green of fresh young leaves. This is good for bedrooms and living rooms alike, Dead white is fatiguing to the eyes, and best avoided. It is excessively foolish to read with the eyes facing a source of light, especially as the light is anything but diffused. We should read with the light behind us, passing over one shoulder or the other—the left shoulder, of course, when we are writing.

So far as children are concerned, we must remember that the great majority of them are far-sighted when they are very young, and that therefore the strain of using their eyes at short distances is even greater for them than for us. The fact that the child is far-sighted ought to be hint enough to us that the best employment for its eyes at early ages is not at short distances. Few and short stretches of reading and writing are all that we ought to require of these young eyes. On the whole, the best work for a small child is its play, and its best play is open-air play with balls and hoops, and so on.

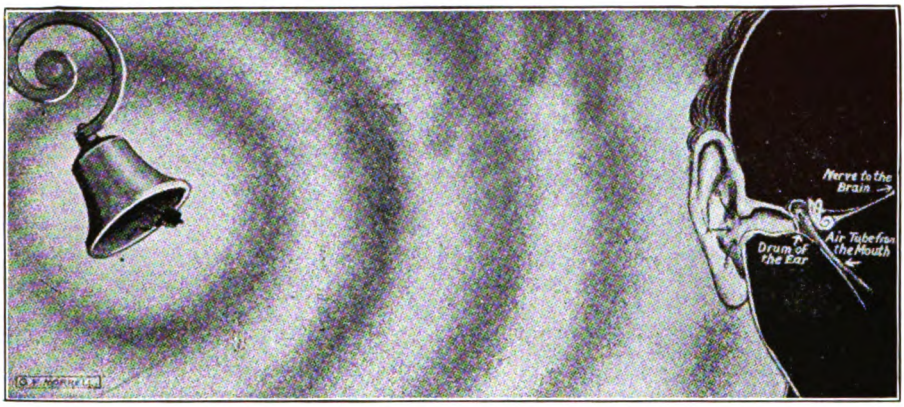
When children are obliged to read, we must remember that they are taking certain risks with their eyes. We should take great care of the lighting arrangements; we must provide glasses if the child is too far-sighted; we should be most careful to use large type deeply printed; and, in any case, the periods of reading should be brief. It is much better to employ some kind of print that makes the letters in very simple shapes.

WHAT THE EYES SEE WHEN READING

When we come to think of the case of a printed page, we shall see that the letters which we distinguish are the only places where the eye does not not see. What we see when we read is not the black, but the white; the letters are not really anything that we see, but gaps in our seeing. As the white occupies a great deal more space than the black, it is evident that our eyes would be much less fatigued if the state of things were reversed, and books were printed in white letters on black paper. If that were so, the eye would be rested everywhere except where there were the letters which it wishes to see.

But reading is not the only use for the eyes, and there are a great many people who think that, while we spend so much time upon reading, we are forgetting to keep our eyes open in other ways.

The time may come when the education of the eye in other matters than reading will always be included in the upbringing of any child. The time for this education, as for every kind of education, is youth, and one great difference between this kind of education of the eye and the kind that has to do with reading and writing is that it is much more suited to the young eye.



This diagram shows us how the sound-waves travel in ever increasing circles and how the outer ear collects the waves as shown by the arrows, A, B, and C, directing them inwards so that they will strike the drum.

THE MARVEL OF HEARING

WE know something of the brain and the spinal cord, which together are called the central nervous system, in the upper part of which the Self of man resides. But when we study the history of the central nervous system, we find that it has been developed from the surface of the body, and this fact in itself argues—as all the other known facts do—that its first business is to receive communications from the outside world.

At the present time these communications take very definite lines, which we call the senses. It is by the senses that we gain all our knowledge of outside things, and it is upon the delicacy of the senses that, in the first place, the high development of the human being depends.

We have reason to believe that this delicacy is, in the main, a matter of the brain itself, rather than of the channels from the world to the brain. But, in any case, it must be distinctly understood that this quality of sensitiveness is so invaluable that all the higher qualities of mankind are built upon it. It is, no doubt, possible to be unduly sensitive—sensitive to a degree that upsets the balance of the mind; but, then, nearly every good thing can be exaggerated.

One of the most horrible consequences of what we at present call education, and of the dull routine through which so many of us are put, is that the beautiful delicacy of sense that enables children to respond to what is new, and to notice the small differences between things, becomes spoiled; the edge is blunted, so that many grown-up people go through the world having lost the sense of appreciating everything which made it such a beautiful, wonderful, and interesting place when they were children. Some day, when we learn more about ourselves, we shall find better ways than those at present adopted in educating and dealing with children, and then we shall get better results.

And now let us go on to study, one by one, our senses, or highways of knowledge. It probably does not matter very much which sense we begin with, for the great principles are

the same in every case; only we may begin by noting the names of the various senses, and especially by distinguishing between the senses which communicate with the outer world and certain other senses which do not.

THE SENSES BY WHICH WE KNOW THE OUTER WORLD

The senses which communicate with the outer world are—seeing, hearing, taste, smell, and touch. But nowadays we have learned that it is not sufficient merely to say touch, for there are several senses in the skin besides mere touch. We must at least add the heat sense, the cold sense, and the pain sense to the sense of touch.

In addition to these senses which communicate directly with the outer world, there are other senses by which the brain is informed about the body. Of course, in a way, we may say that, so far as the brain itself is concerned, the body is part of its outer world. These senses come from the organs inside the body, from the muscles and joints, and from certain wonderful little canals in the inner ear, which we shall study later.

HEARING

Now we can take the senses one by one, and we shall begin with hearing. We know that there is a special part of the brain concerned with hearing. If we were to use the word ear for the part of the body that really hears, we should certainly have to say that the real ear is in this part of the brain.

THE REAL EAR IN OUR BRAIN THAT CANNOT HEAR AT ALL

But we are quite certain that sound cannot be heard directly by this real ear in our brain. The part of the brain where we feel touch feels nothing if it is itself touched, and this is true of the senses generally. The brain only responds if the communication is made to it through the proper channel. So what we now have to study is the channel that leads from the outside to the hearing center in the brain. Perhaps the best use of the word ear would be to describe the whole structure, from the surface of the body to the tiny nerve cells where the hearing is actually done.

If we begin at the surface of the body, we find in ourselves and in most of the higher animals a pair of organs projecting from the head, which are the only parts of the organs of hearing that we can see, and which we therefore call the ears, though they are by far the least important part of the whole organ of hearing, especially in ourselves. We have all observed a dog prick up its ears, and so we learn that the real use of the ear—or, as we should properly say, the outer ear—is to catch waves of sound.

It is the general rule that the outer ear is provided with small muscles by which it can be moved in various directions. This serves two purposes. First, it enables the animal to make the most of the sound that comes to it, for the sound-waves are, to a certain extent, gathered up by the outer ear, and so are made rather more intense.

WHY ANIMALS PRICK UP THEIR EARS AT ANY SOUND

But the second great advantage of being able to move the outer ear is that it greatly helps to decide where a sound comes from. This is of great importance to such an animal as the antelope, which hears a sound and fears that it may mean the approach of some danger. We all have opportunities of observing how animals prick up their ears, and we can imagine them saying to themselves: "Where does that sound come from?"

It is very interesting to find in ourselves three little muscles attached to the outer ear, by which it ought to be pulled in various directions. These

muscles exactly correspond with those that we find in the lower animals, but in ourselves they have quite fallen out of use. Though they are small, they are still quite capable of moving the ear; but we do not use them. A few people have the power of moving one or both outer ears at will, but there is no record of any human being who ever moved his outer ears when he was straining to hear a sound, or when he was trying to judge the direction of a sound.

We are able still to judge the direction of a sound, but we cannot do so as well as do the lower animals, and the reason, no doubt, is that our outer ears no longer help us. Still, we are able in some degree to compare the intensity of a sound in the two ears, and so we judge more or less where it comes from. If the sound is made at a point equally distant from both ears, we are quite at a loss. A simple and amusing experiment or game will prove this.

AN AMUSING GAME THAT TEACHES US A LESSON IN SCIENCE

If someone is blindfolded, we can seat him in a chair and then make little noises, and ask him to judge where they come from. As long as they are on one side he will judge all right; but if we make the noises at the back of his neck, in the middle line of his body, or under his chin, he cannot tell the one from the other.

If we try this experiment on one of those people who can move their ears, we shall find that he does not use his power for this purpose. But one of the lower animals could not possibly be deceived in such a case. By pricking its ears forwards and back, it would in a moment discover in which direction it heard the sound best. It would have no more difficulty in this case than when the sound was on one side. When the sound comes from the side, the animal judges, as we do, mainly by comparing the intensity of sound in the two ears.

THE CENTERS OF HEARING IN THE BRAIN THAT COMPARE NOTES

This seems very simple, and we none of us have any difficulty in doing it; but it is wonderful, all the same, that the two hearing centers should be able to compare notes, so to speak, and when the left hearing center hears loudest we should turn to the right, and when the right hearing center hears loudest we should turn to the left. This is so because most of the nerve-fibers cross the middle line of the body on their way to the brain.

The outer ear is not entirely useless even in ourselves, for if it is all filled up except just at the opening of the canal that runs inwards, we hear less clearly. This experiment can easily be made. It shows us that to some small extent the outer ear is still useful as a sort of ear-trumpet, though vastly inferior to that of most of the lower animals.

From the outer ear there leads a little channel, along which the sound-waves pass. When we cleanse our ears, we cannot and do not wash this channel. It would be a very serious matter if we had to do so, for there would be grave risk of doing harm at its inner end. Yet, as a rule, this channel is kept perfectly clear and open, even though it is never washed. It is lined by tiny glands which produce a sort of wax, and as this wax passes outwards it carries impurities away with it. We think of this wax as a rather unpleasant thing; but in reality it is a beautiful means of cleanliness and protection. At its inner end this canal is closed entirely by a thin, delicate membrane, which is exactly like a drum-head, and it is called the drum membrane or *tympanum*.

THE GREAT IMPORTANCE OF THE DRUM MEMBRANE

This membrane is exceedingly important for the purposes of hearing, and it is a delicate thing. If it is injured, it is, as a rule, injured permanently, and the hearing is affected. It may be injured either from within or from without. Sometimes little children push beads or peas into their ears, and they may do much harm in that way. A child might have reason to regret for its whole life such a foolish action. When anything like a bead has been put into the ear, we should call in the doctor at once and not attempt to get it out ourselves.

This precious drum membrane of the ear is also liable to be injured from within; and earache in children, or indeed in anyone, should not be neglected, because it means, as a rule, more or less of a threat against the health of the ear-drum. We shall understand this better when we see what is on the inner side of the membrane.

If we could see beyond the membrane we should find that it made one of the walls of a little space, or chamber, hollowed out inside one of the bones of the head. This space is known as the middle ear or tympanum. The bone in which it, and also the inner ear, lies is called the petrous bone, from the Greek word for a rock, because it is the hardest bone in the whole body. This is interesting because a hard bone must undoubtedly conduct waves of sound very much better than a softer one.

THE LITTLE TUBE THAT RUNS FROM THE THROAT TO THE EAR

This middle ear is filled with air, and naturally we must ask where the air comes from; the answer is that it comes from the throat. There runs from the back of the throat on each side a little tube which goes to the middle ear and conveys air to it. If we shut the mouth and hold the nose, and then make a sharp movement as if we were sneezing, we can feel something happening in our ears. This is because when we made that movement we opened the little tubes, and drove some air along them into the middle ears. It is a very important thing for the safety and health of the ear, and also for the immediate purposes of hearing, that the air pressure on both sides of the drum of the ear should be the same.

If the air pressure were greater on the outside than the inside of it, the drum membrane would be driven inwards and strained. If any disturbance in the throat or nose closes up these canals, so that air cannot get along them, this is liable to happen.

WHY A COLD IN THE HEAD CAUSES DEAFNESS

Everyone knows that a cold in the head often causes deafness. The reason is that the cold, as we call it, spreads along the tubes that run to the ear. The lining of them becomes swelled up, and so they are closed, and cannot do their duty of keeping the air pressure of the middle ear the same as the air pressure outside. Hence the drum head of the ear is strained and cannot vibrate as it should do to soundwaves, and so we are deaf for the time. In more serious troubles of the nose and throat, such as may happen in scarlet fever, the middle ear may be invaded by the disease, and the drum head may be broken through, and deafness for life may result. It is probably quite fair to say that proper care and treatment from the first could prevent this very unfortunate result in every case.

But the most remarkable thing that we find in the middle ear is a little chain of three tiny bones, much the

smallest bones in the body, which are there for a very special purpose. They are called by Latin names, which mean the hammer, the anvil, and the stirrup, and the stirrup especially is exactly like its name. The handle of the hammer lies against the drum membrane; the hammer is jointed to the anvil, and the anvil to the stirrup. The foot of the stirrup rests against a membrane which separates the middle ear from the inner ear, which is the most wonderful place of all.

How the hammer, anvil, and stirrup carry sounds to the inner ear

The business of this chain of bones is to carry sound-waves across the middle ear. That is why it has to be filled with air, for otherwise they could not vibrate freely. Every time a sound-wave causes the drum membrane to vibrate, it sets in motion the hammer bone which is fastened to it, and so the vibration goes on. If the joints between the bones become fixed, the hearing is spoiled in some degree. This may happen in old age.

Lastly, we find two muscles, very tiny but very useful, which pass into the middle ear. They have opposite uses, and we call them into action—though we know nothing about it—according to whether we want to hear a sound more acutely or less acutely. One of them is so arranged that when it pulls it tightens the drum membrane. That makes it vibrate more energetically, and so we hear better. Whenever we strain to hear, we throw this little muscle into action. It is called by doctors the *tensor tympani*, which simply means the stretcher of the drum.

The other muscle has just the opposite effect. It is attached to the stirrup bone in such a way that when it pulls the bone cannot vibrate as well as usual. So when this muscle is in action it interferes with the conduction of sound to the inner ear, and when a noise is unpleasantly loud we throw this muscle into action. It is noticed that in certain cases when there is anything the matter with the nerve that supplies this muscle, loud sounds become unusually painful.

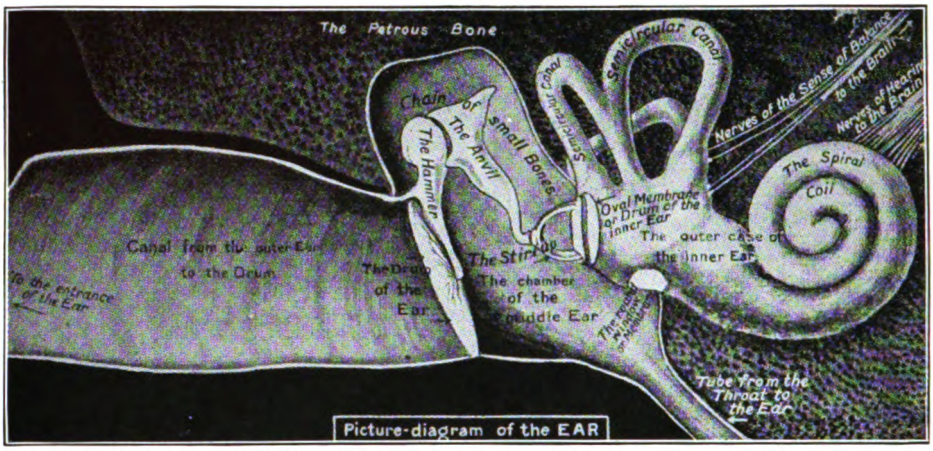
That is all we need say about the middle ear. The more closely we study it, the more wonderful we find it, and we become almost inclined to think that there can be nothing quite so exquisite and perfect in the whole body until we come to study the inner ear, compared with which the middle ear is almost clumsy. The whole purpose of the chain of bones in the middle ear is to carry the sound-waves from the membrane in its outer wall to a similar sort of membrane on its inner wall, on the inside of which is the inner ear. The inner ear is filled with fluid, and every sound that we hear reaches the nerve of hearing by conduction through fluid.

We think of sound as a wave in the air, and that is what it usually is; yet in its last stage, before reaching our nerves, every sound we hear is made of waves in water. This has a special interest if we trace the history of the ear and notice how it has slowly developed from its early stages in the fish, which hears sound-waves conveyed by water.

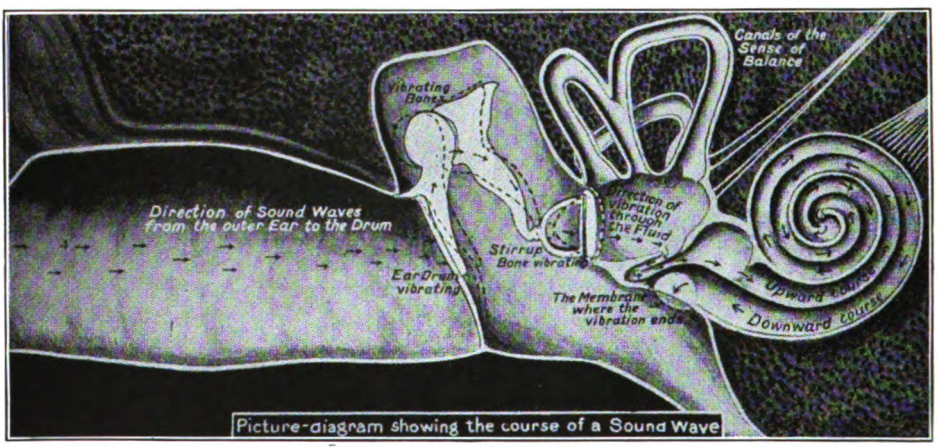
The inner ear that is far more wonderful than the outer ear

The main part of the inner ear is a tiny and very delicate bony structure, rather like a snail's shell. We must understand that all this is filled with fluid. When the foot of the little stirrup bone is thrown into vibration by a sound, it vibrates the membrane to which it is attached, and so there is started a series of rapid little taps to

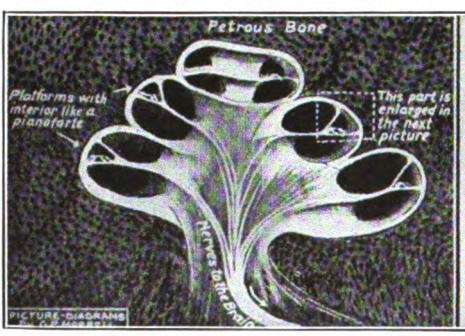
THE WONDERFUL MACHINERY OF OUR EARS



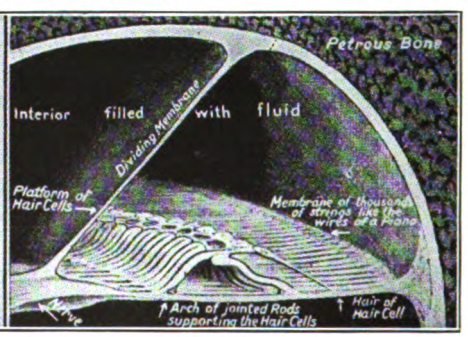
This diagram shows the inside of our ear, from the entrance to the end of the nerve that passes to the brain. The drum is stretched across the end of the canal, and on the other side is the chamber of the middle ear, filled with air that enters from the throat. In this chamber are three small bones, the hammer, the anvil, and the stirrup, the last being fixed to the drum of the inner ear, which is shaped like the coils of a snail's shell.



Here we see a sound wave striking the drum of the ear. The vibration moves the handle of the hammer, which pulls the anvil and pushes the stirrup, as shown by dotted lines, against the drum of the inner ear. Tiny waves of the fluid inside this inner ear pass through a membrane which lines the shell, and, traveling round the coils in the direction of the arrows, communicates its sensation to the nerve, and then returns by another canal.



In this picture the spiral coil is cut through from top to bottom. The little galleries are filled with fluid, and contain very marvelous organs. The part in the dotted square is shown in the next picture enlarged.



Over 3000 little hammers, jointed like those of a piano, support thousands of hair-cells that rest on a membrane. More than 10,000 strings are stretched across, like piano wires, and these convey the wave sensation to the nerve.

the fluid which is lying against the inner side of that membrane, and the waves thus started run right along this spiral coil.

Now, when we carefully examine the inside of this coil with the aid of a microscope, we shall find that we have really come to the essential part of the machinery by which sounds are received. All the rest that we have studied is merely for conducting the sounds. The outer ear, the canal leading from it to the drum, the chain of bones, and the spiral canal filled with fluid, are all mere arrangements for getting the sound in the best possible way to the ends of the nerve of hearing. We may compare all these parts of the ear with all the front parts of the eyeball. These front parts simply serve to carry the light to the curtain at the back of the eye, where the nerve of vision begins or ends, whichever way we care to look at it. And the same is the case with the ear.

THE FIBERS OF THE INNER EAR THAT ARE LIKE PIANO WIRES

But we have not yet actually reached the ends of the nerves of hearing. The little nerve fibers do not hang freely in the fluid of the spiral canal, for there is something in between. We find that along the whole length of the canal, stretched across it from side to side, there is a sort of platform made of delicate fibers. Their number runs into many tens of thousands.

If the spiral were arranged flat, in a straight line — which it doubtless would be but for the fact that a spiral takes up less room in the head —we should see that the fibers are very like a series of piano wires, or like those toy musical instruments made of strips of metal that are struck with little hammers. Many people suppose that there is a meaning in the resemblance of these fibers to a musical instrument.

There are cases where people have been perfectly deaf to one or two notes of the piano, but could hear all the notes above and all the notes below, and in some of these cases it has been found that the piano in the inner ear, so to speak, has been damaged in a way corresponding with the gap in the person's hearing.

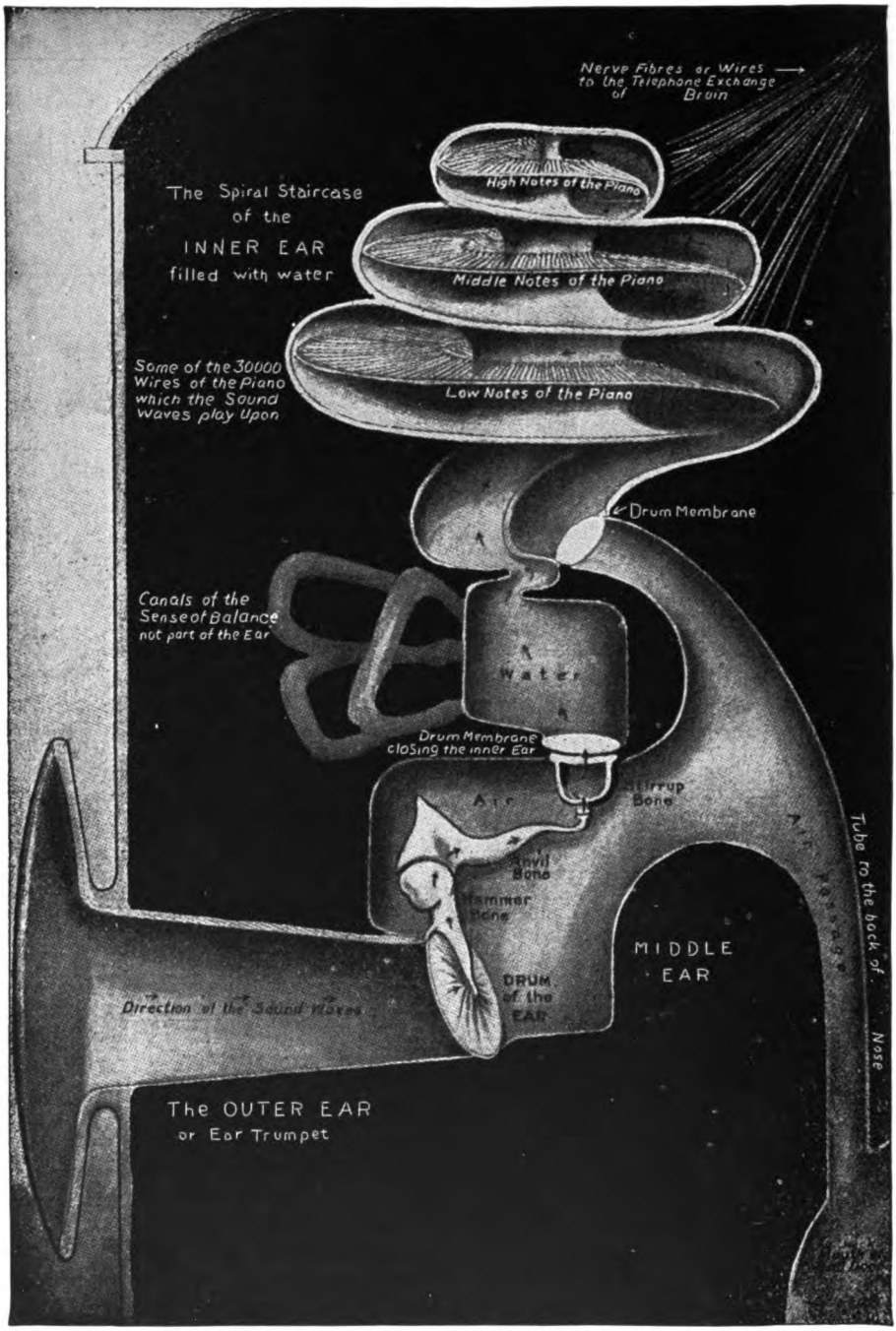
THE LITTLE FINGERS OF THE EAR THAT RECEIVE THE WAVES OF SOUND

Now, upon the whole length of this series of fibers there are perched a number of small but wonderful cells, each of which has a few little things like short hairs sticking out from it, and these little fingers, or hairs, lie in the fluid of the spiral canal. Probably it is these tiny, hair-like fingers that receive the waves of the fluid, and then something happens in the cells. Lastly, if we examine carefully the lower part of each of these cells, we find that the nerve of hearing, which has come to this place from the brain, has sent a few tiny fibers that end at the base of these cells. The fibers do not run into the cells, but the cells are perched upon the ends of the little nerve fibers.

THE JOURNEY OF A SOUND FROM THE OUTSIDE WORLD TO THE BRAIN

Now we have actually traced the sound from the outer world to the ends of the nerve of hearing. We have seen the path of its conduction, sometimes along canals filled with air, sometimes along little bones, then along the canal of fluid, and lastly, through their hairs into certain special cells made for the purpose. Here we come to a point which very few people understand, and as it applies equally to all the senses, we must know it thoroughly. We might suppose that the next thing to happen would be that the sound, having got so far, runs

HOW A SOUND REACHES THE BRAIN



This picture shows the wonderful structure of the ear—the telephone receiver by which we are able to receive messages from outside. Sound-waves of air strike the drum of the ear, which vibrates the bones of the middle ear, and they in turn vibrate the drum of the inner ear. This sets in motion a fluid, and the wave motions are conveyed along the spiral staircase to the wires, or nerves of hearing, and from there to the telephone exchange, or brain.

along the nerves of hearing to the brain. Nothing of the sort occurs.

Hitherto we have been dealing with things that are wonderful and complicated enough—so complicated that what has been said is only a mere outline of the facts—but at this point we have reached something compared with which all the rest is commonplace and simple.

The sound which reached the hair cells of the inner ear does not pass along the nerves of hearing, but it sets up in them a nerve current which runs to the brain. That nerve current is not a sound wave; it is utterly different in every way from a sound wave. But it is that current, and that alone, which excites the hearing cells in the brain, and enables us to say that we hear.

If we examine the nerve of hearing through a powerful microscope, it looks just like any other nerve. But to say merely that it is capable of carrying a nerve current which we translate into sound is not to state half the mystery, for we must consider the infinite variety of sounds that we can hear and distinguish.

THE MANY NERVE-CURRENTS THAT PASS TO THE BRAIN WHEN WE HEAR MUSIC

What must be the number and delicacy and variety of the nerve currents passing along these nerves of hearing when a great musician conducts a big orchestra, and can hear every instrument separately, and know whether it is in tune or not! How delicate must be the varieties of current that are possible when we remember that it is scarcely possible for us to mistake the voice of one friend for that of another.

So long as we confine ourselves to the study of the inner ear, and see the tens of thousands of fibers of different lengths, and the hundreds of thousands of hair cells which it contains, we are not so much puzzled, because here is something which seems to correspond with the sense of hearing.

There ought to be the power of noticing slight differences in sounds by means of an organ so complicated as the inner ear is. But the inner ear would not be of the least use without the nerve of hearing, and every one of these tiny differences in sounds means a tiny difference in the something that runs along the little white threads that make up this nerve.

THE GREAT MARVEL OF NERVE-CURRENTS THAT VERY FEW PEOPLE THINK ABOUT

Language cannot say how wonderful these things appear to those who really think about them; and it is a great pity that so many of us should go through the world, hearing, seeing, and moving, and yet never giving a thought to these marvels upon which our lives depend.

The fact that nerve currents, and not sound currents, travel along the nerve of hearing is a general truth of all the senses. It is not light that travels along the nerve of vision. The place in the brain where we see is enveloped, and lives always in utter darkness; no light ever reaches it. What reaches it is the nerve currents from the nerves of vision. All that the light does in entering our eyes is to do something which starts those nerve currents in the ends of the nerve of vision.

And all that sound does in entering our ears is to start certain nerve currents in the ends of the nerve of hearing. When we study the variety of sensations that are possible for us, we see that a nerve current, though we talk about it so easily, must be nearly the most complicated and wonderful thing in the world, compared with which the waves of sound, or light, or electricity, must be considered quite simple.

HOW THE BODY IS HELD IN BALANCE

THE inner ear would be quite sufficient to make the bone that contains it the most wonderful in the body. We know that that bone is the hardest in the body; and this is necessary not only because it forms part of the base of the skull and should be strong, but also, we suppose, because a hard bone conducts sound waves better than a more loosely-built one.

We must understand that the important thing in hearing is for sound waves somehow or other to get to the hair cells. Much the best way is through the fine series of structures about which we have read; but though they are very useful, and though we cannot hear anything like so well without them, they are not necessary.

From the teeth, or from the bones of the head in general, sound waves can be conducted—and, of course, are conducted, whenever we hear—which are conveyed very well by the dense bone that contains the inner ear, and so get to its hair cells. Sound waves reaching the ear in this way contribute to the keenness of our hearing, but of course they cannot compare for effectiveness with those that travel along the wonderful path made for the special purpose of hearing.

But there is another reason why the bone that contains the inner ear is of very great importance and interest. It also contains another organ of a wholly distinct sense, which lies close beside the inner ear, and is, indeed, in more or less direct communication with it. For many years it was supposed that this organ was part of the inner ear, and was concerned with hearing. We now know that it has nothing to do with hearing.

The mistake was made more natural by the fact that one and the same nerv seems to run from the brain to both parts—as they were supposed to be—of the inner ear. In point of fact, what looks like one nerve, and is still called one nerve, is two wholly distinct nerves, as we can readily prove if we trace the course of the fibers towards the brain.

We find that the fibers which have come from the real inner ear all run to a certain part of the brain, the business of which is hearing. But we find that the fibers which have come from this other organ all run to an entirely different part of the brain which has nothing to do with hearing at all.

In fact, what we are here dealing with is the sense of balance, and it is probably more or less of an accident that its machinery happens to be such a close neighbor to that of the sense of hearing.

A LITTLE-KNOWN PART OF OUR BODY THAT HELPS US TO STAND

This sense of balance is, in a way, a sense that tells us about the outside world, like hearing or vision; because it does tell us where the outside world is in relation to our bodies. But it is quite unlike the senses we know so well, as it is not arranged to receive anything from the outside world at all, and so, unlike the eye or ear, it has no connection with the surface of the body. We may say that this is one of the senses which tells the brain about the body, rather than about the world outside the body.

Before we study the organ of this sense, we must notice, in the first place, that it is helped by other means. We do not entirely depend for our balance upon the organs of balance in the base of the skull, though we certainly cannot balance ourselves with-

out their assistance. When we stand, for instance—and standing is a very much more difficult matter than we usually suppose—our power of balance is greatly helped by the feelings we get from the soles of our feet. If something is painted on to the soles of our feet so that the skin there can no longer feel, or in cases of illness which have the same result, we cannot stand so easily as we usually do.

But the sense of balance is also helped by the eyes. As long as the eyes are open, even a person who is not helped by the soles of his feet may balance himself; or, with his eyes shut, he may yet balance himself if he stands with his feet far apart; but if he puts his heels together, and shuts his eyes, he will probably topple over on the ground.

THE GREAT USE OF THE EYES IN BALANCING THE BODY

People, however, can stand with their heels together, and with their eyes shut, thus doing without the assistance of sight, if the organs of balance in the skull are all right, and if guidance is also coming to the brain from the soles of the feet, and also from the muscles and joints of the legs. If we set ourselves the task of balancing on a very narrow plank, or, still more difficult, on a tight-rope, then our eyes become more useful, and, unless we are very skilful indeed, they are quite necessary.

Everyone knows how the tight-rope walker keeps his eyes steadily fixed on a certain point, and so greatly helps himself. If he is very skilful, he may walk on the tight-rope even though he bandages his eyes; but this is far more difficult. However, the eyes and the feelings from the skin and joints and muscles are all unimportant compared with the guidance we get from the special organs of balance, and no one was ever yet able to stand or walk on the ground, much less on a tight-rope, in whom these organs were not working properly. Now we must learn what they consist of.

In the hard bone that contains the inner ear, and close to the inner ear—on each side of the head, of course—we find this organ of balance. It consists of three tiny tubes, in shape like half a circle.

THE SIX LITTLE TUBES WHICH TELL THE BRAIN OUR MOVEMENTS

The proper name for a half circle is a semi-circle, just as half a tone is a semi-tone, and the corresponding adjective is, of course, semi-circular; not a difficult word if we know how it is made up. The proper name for these tubes, then, is the semi-circular canals, and of these the head of every human being and of all the higher animals contains six, three on each side. They are all filled with fluid.

Just as the nerve of vision runs to the eye and the nerve of hearing to the ear, so the nerve of balance runs to the semi-circular canals. The ends of the nerve—that is to say, the ends of the countless nerve-fibers which make the nerve—lie close to the fluid that fills the canals, and if that fluid moves, or if the pressure on it changes in any direction, the nerve-fibers know about it and tell the brain our movements.

Now let us look at an ordinary child's block, which we call a cube. If we want to measure it, we find that it can be measured in three directions—from top to bottom, from side to side, and from back to front. We may pick up any solid thing and we find the same is true of it. We may want to measure a room, and we find again that the same is true; we must measure the floor in both directions, and we must also measure the height of one of the walls.

A BLINDFOLDED MAN'S WALK ACROSS NIAGARA

One of the most marvelous feats of balancing ever performed was the crossing of Niagara Falls by Blondin, who walked across the Falls on a tight-rope, blindfolded. The eyes are very helpful in enabling us to keep our balance, but they are not really essential, and Blondin was able to walk over Niagara with his eyes covered, being aided by the six little canals in his head, which are the organs of balance, as described

In general terms, space has three directions—or dimensions, to give the usual word—and when we move our head it must move in one or more of those three directions. We may nod our head, or we may shake our head, or we may raise it up and down. All the possible movements of the head are either in one of these directions or in a combination of two or all three of them. Now, the business of the organ of balance is to acquaint the brain with every possible movement of the head, and it must therefore be so constructed that all possible movements shall duly register themselves in it.

This is done in the most exquisite way by the provision of three canals on each side of the head, these three canals being arranged in correspondence with the three dimensions, or directions, of space. One canal lies on its side or is horizontal; and the other two are upright, but at right angles to each other. As there is an organ of balance on each side of the head, we may think of the canals in pairs, and there is no doubt that they act in pairs. For instance, the horizontal canal on each side of the head acts with its fellow when we shake the head, or when we spin round, as we do in dancing.

THE MOVING FLUID IN THE SIX LITTLE CANALS IN OUR HEADS

The consequence of this arrangement is that every possible movement of the head has a strictly corresponding effect upon the fluid inside one or more pairs of these six canals, and the center of balance in the brain is informed. This center of balance probably exists in the cerebellum, or little brain. Sometimes we have an illness in which the organ of balance is thrown out of action, and just as a person whose eyes are injured cannot see, so those in whom the organs of balance are injured cannot balance. They suffer from persistent giddiness.

It has also been proved that where the injury affects only certain of the canals, the giddiness corresponds to the direction of the particular canal or canals in question. If it is only the horizontal canals that are thrown out of action, then we shall be all right so far as nodding the head is concerned, but directly we start shaking it, we shall become giddy, and, if we do not receive support, topple over.

The history of the semi-circular canals is deeply interesting. The lowest kind of creature with a backbone, as we know, is the fish, and we find in it no trace of these canals. Now, the fish is very clever at balancing itself, and shows no signs of giddiness; but probably we can explain why the fish manages so well without any semi-circular canals, if we remember how great the pressure of water is upon the surface of the fish, and therefore how much more information the fish must get from its skin than we are able to get from ours.

HOW BIRDS ARE ABLE TO FLY WITHOUT TUMBLING OVER

As we ascend the scale of backboned animals, we gradually find the appearance of these semi-circular canals, though they do not all appear at once. If our statements as to their use are correct, we should expect to find them most beautifully and perfectly developed in birds, which could not succeed in flying without a perfect sense of balance. In flying, the bird gains little from the feet and legs, as we do in the very much simpler business of standing or walking; and therefore its need of special organs of balance is all the greater.

So we find the semi-circular canals at their very best in birds, and we know also that, just as in our own case,

if the canals are thrown out of action, the bird's power of balance is destroyed, and in flying it will make mistakes and show peculiarities corresponding to the particular defect in its organ of balance. It is probable that in this way we can explain the peculiarity of what are called "tumbler" pigeons.

It used at one time to be thought, before these newer facts were discovered, that the semi-circular canals must have something to do with hearing; and we can understand how natural this idea was, seeing that the canals look as if they were part of the inner ear, and their nerve looks as if it were a part of the nerve of hearing.

THE LITTLE ORGANS IN OUR EARS THAT HAVE NOTHING TO DO WITH HEARING

The idea used to be that probably we somehow judge of the direction of sound by means of these semi-circular canals. No one could look at their odd arrangement without feeling that their business had something to do with direction. But we now know that their business is with the direction in which the head moves, and not with the direction of sound. It is much more important to know what the head is doing than to know where sound comes from, and, in any case, by having external ears that can be moved, a creature can easily enough judge of the direction of sound without any special machinery inside its head. If we human beings are not so well off in this respect, it is because we have lost the power of moving our outer ears like the animals.

THE FISH'S GILLS, UPON WHICH MANY PRECIOUS STRUCTURES ARE BUILT UP

We have lost this power that the animals have, but we have gained many things that the animals have not. In the very lowest vertebrate animals, such fishes, we find, instead of lungs, have what are called gills. To these the blood runs, as it runs to our lungs, and in them it comes in close relation with the oxygen dissolved in the water, just as in our lungs the blood comes in close relation to the oxygen of the air. The gills have to be supported on something, and so we find in the fish five gill-arches, with slits between them called gill-slits.

HOW THE SWIM-BLADDER OF THE FISH BECAME THE LUNG OF THE MAMMAL

We can never tell what uses nature will turn a thing to, and the history of life upon this earth proves over and over again that organs which would appear to have lost all their use, and of which nothing could be made, may be turned to new and utterly different purposes, rather than be wasted. Nature took the swim-bladder, which used to be filled with air, and helped the fish to swim at the level it liked, and when the creature no longer swam under the surface at all, she made it into a lung. Thus nature had gill-slits and gill-arches thrown on to her hands with their occupation gone. By long and careful study of many animals we have been able to trace what happens to each of these; and it is one of nature's great triumphs in the development of the bodies of the higher animals that she has been able to do with these apparently useless things.

Out of them has been made the whole of the semi-circular canals. Thus nature has provided for the balance of the bird out of the organs which helped the fish to breathe. From these organs, also, she has made the whole of the ear, including the little bones in the middle ear, and all the wonderful structure of the inner ear. As if this were not enough, she has also made out of the gill-arches an organ no less new and wonderful than the voice-box, or larynx, by which we speak and sing.

THE VOICE AND ITS MECHANISM

IT IS much better, for two good reasons, that we should go on to study the larynx. First, we should do this because then we shall be studying together the various organs that have been developed in the higher animals from the gill-arches of the fish; and, secondly, we should do so because it is well to study the means by which we produce sounds, after studying the means by which we hear them.

We all know something, at least, about the larynx, because we have all seen the front part of it pushing the skin forward and sometimes moving up and down. There is a foolish notion that this is the apple which Adam swallowed, and which stuck in his throat, and so it is sometimes called Adam's apple. A larynx, or voice-box, similar to ours is to be found in all the higher animals, and, as we know, it is simply a stringed musical instrument. In the case of the birds, many of which have such beautiful voices, there is besides this stringed instrument another, which is practically an organ pipe. But, in all its forms, and whether with or without this organ pipe, the larynx is evolved from one of the gill-arches of the fish.

This voice-box, of course, is not only concerned with speaking and singing; it has important duties to perform every moment of our lives, because it is the channel of the breath of life. Further, owing to the manner in which the lungs have been developed in long-past ages, it has so occurred that the opening from the throat to the voice-box lies in front of the opening from the throat to the gullet.

Only the study of the way in which living things have developed one from another can enable us to see any meaning in this arrangement, which, as we know, makes it necessary for everything we swallow, whether liquid or solid, to be thrown over the opening to the larynx without entering it. There is thus placed upon the larynx another duty besides that of producing sound, and that of attending to our breathing, for it has to protect the air passages every time we swallow. This organ is made of pieces of what is called cartilage. Our ordinary name is gristle, and we may describe it as something which is half way towards bone.

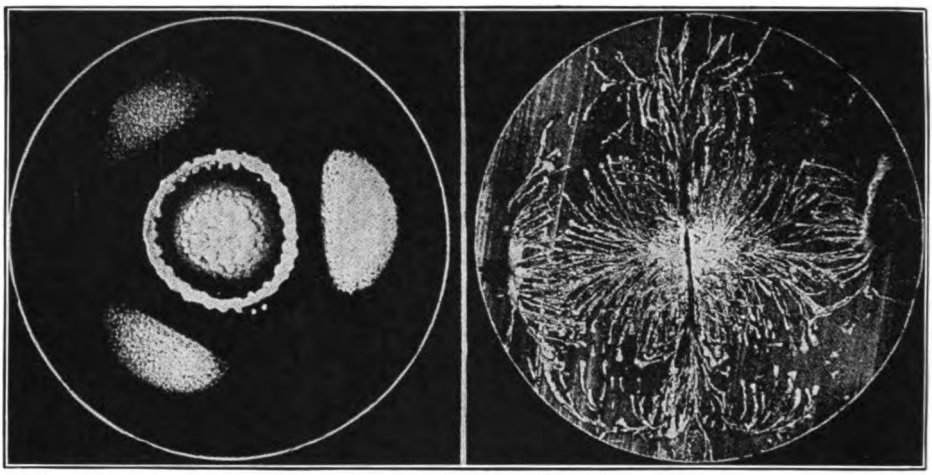
THE NARROW CHANNEL THROUGH WHICH PASSES ALL THE BREATH OF LIFE

In old age the cartilages of the larynx get to be not exactly bony, but more chalky and rigid than they are in youth; and this, probably, is one of the reasons why most people with sensitive ears can readily distinguish a young voice from an old voice.

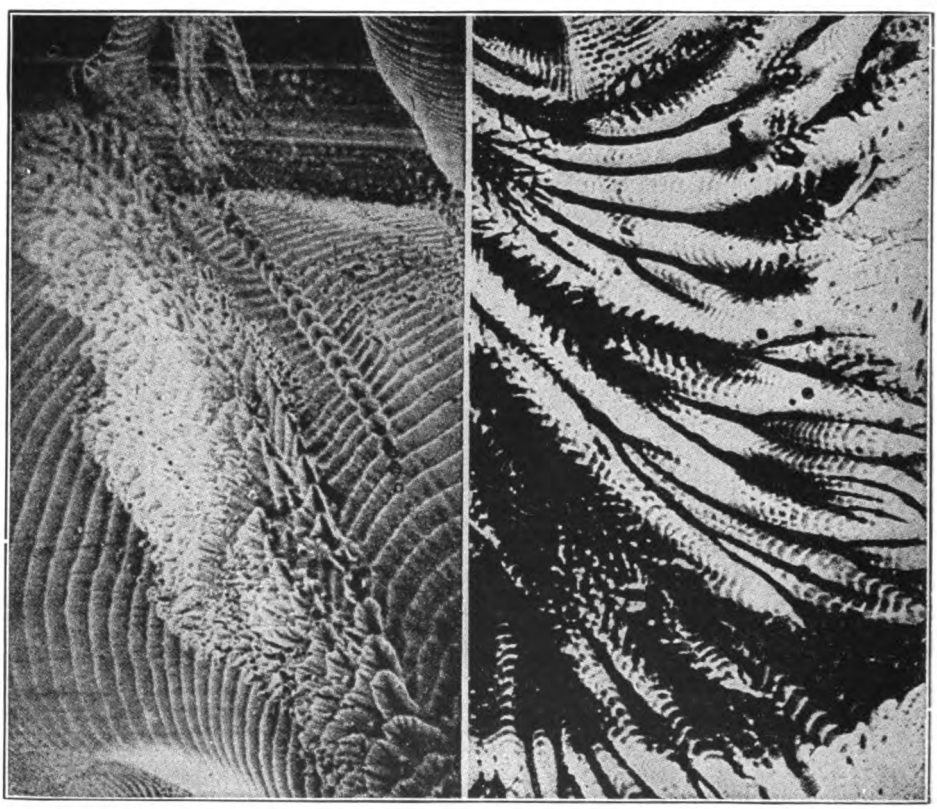
The business of the larynx is to support and control the action of two tiny cords or strings called the vocal cords; that is to say, the voice cords. The picture given in connection with this article shows what the vocal cords look like when they are seen from above by means of a bright little mirror held at the back of the throat. We see that the vocal cords have a free edge towards the middle, and that from it they pass outwards to the sides of the larynx.

All the air by which we live passes through the narrow space between the vocal cords. The arrangements by which they can be put together or separated are quite simple. They part every time we breathe in, and when we choke and cannot breathe in, it is because the vocal cords are not parting as they should. But if the cords are to produce voice, they

PICTURES DRAWN BY THE HUMAN VOICE



No artist drew these designs. A thin sheet of india-rubber was stretched over a vessel like a cup which had a spout at the side. Some light powder was then thrown upon the rubber covering, and when someone sang into the spout, the powder formed itself into the design of the picture on the left. The right-hand picture, looking like a frosted window, was drawn in the same way, but, instead of powder, moist paint was put on the rubber covering.



To obtain the left-hand picture, a sheet of glass was coated with paint and put over the cup, with the paint resting on the rubber covering. Then, as the spout was sung into, the glass was moved round, and this beautiful design appeared. The picture on the right—something like a fern-leaf—was made by singing louder and having moister paint on the glass. The cup with a spout or tube is called an eidophone, which means "form of the voice."

must be able to do much more than this. It must be possible to hold them tightly stretched, so that when air is forced against them they will vibrate. Nor is this all, for it must be possible to stretch them in different degrees. As we shall learn when we come to study sound, the pitch—the shrillness or the lowness—of a musical note produced by anything trembling depends upon a number of things, such as its weight, its length, and its tightness.

THE WONDERFUL MUSICAL INSTRUMENT WITH ONE STRING

Now, in the case of a piano, when we want to produce notes of different pitch, we have a number of strings of different lengths laid side by side, so that we can strike the one that gives out the required note. Also, we can have some of them made of much heavier material than others. In the case of the violin, it is possible to have only very few strings, but we can produce all the notes we want by stopping the strings with our fingers, so that the length of string that is free tc vibrate can be altered as we please; and the strings are made of different weight and thickness.

But in the larynx there are only two strings, and these always act together, it being impossible to produce voice with one of them; moreover, they are of the same weight and length. Outside the human body, a musical instrument that had practically only one string, and that could not be stopped at different points like a violin string, would not be able to produce much variety of pitch. The only possible way of getting any variety would be to have some means of varying its tightness. It is probably correct to say that there is no material other than that made by life that can be tightened in such different degrees as the needs of music demand, without permanent injury to the strings.

THE MARVELOUS POWER THAT A GOOD SINGER HAS OVER THE HUMAN VOICE

But though our vocal cords have only the one possibility of varying pitch, due to the fact that they can be tightened in different degree, with this one means they triumph. A good singer can produce all the notes in a range of two octaves, and many singers are able to exceed this compass considerably. Outside the body there is no parallel to this. It is interesting, therefore, to know of what the vocal cords are made, so that they can stand such varying degrees of tightness, within a few seconds, without injury. They are simply made of fibers of what we call elastic tissue, such as is found in various parts of the body wherever it is needed. But an ordinary piece of elastic is rubbish compared with the elastic tissue made by the body.

HOW THE VOCAL CORDS ARE TIGHTENED TO PRODUCE DIFFERENT SOUNDS

The next question is—How is their tightness varied? In front, just behind the part of the voice-box that we see from outside, the cords are fixed to the largest cartilage of the larynx, but, behind, each of them is fixed to a tiny little knob of cartilage which is delicately jointed to the part that it rests on, so that it can be tilted in several directions.

What really happens when we sing is that these little knobs of cartilage are tilted backwards so that the cords are made tighter when our voice ascends in pitch, and are tilted forwards so that the cords are made slacker when our voice falls in pitch.

When a singer is producing one of his highest notes, the cords have to be so tight as to vibrate four times as often in every second as when he is producing one of his lowest notes.

Thus, in the whole range of nature, there is scarcely anything more perfectly delicate than the control which a singer has over this tiny little machine to produce such results.

WHY THE HUMAN VOICE IS MUCH MORE MARVELOUS THAN A PIANO

Nor must we suppose that the singer is merely limited to the number of notes that there are on the piano in two octaves. Pianos vary in pitch, as we know, and a singer can tune his voice to the pitch of any piano he sings with. Skilful singers can produce several tones, even as many as eleven, between two notes that are next to each other on the piano.

As we have said, all this depends on the tightness of the cords, and the tightness depends on the strength with which certain tiny slips of muscle pull upon the cartilages to which the cords are attached; and that depends upon the force of the nerve current sent to the nerves through these muscles from certain nerve cells in the brain. The place, therefore, where the unrivaled delicacy of this machine really exists is the nerve center in the brain.

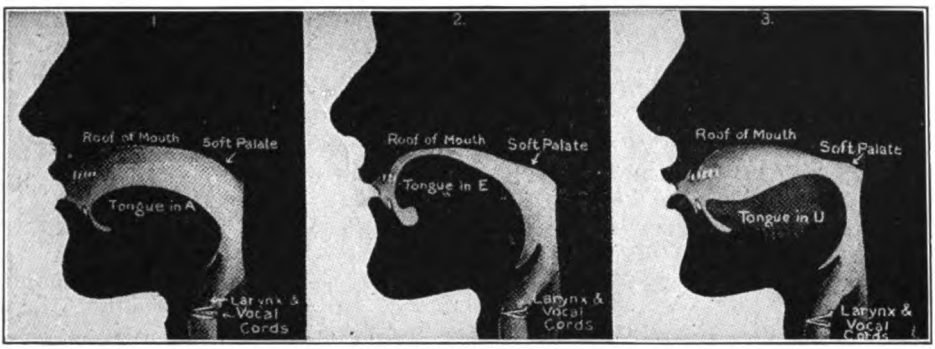
As everyone knows who has tried to read a song he was not sure of, or as anyone may observe who watches a child learning to sing, it is one thing to have all the machinery for producing a note that is easily within the range of our voice, and it is quite another thing to be able to produce that note when we want to. There are two stages of difficulty here, and the second is marvelous beyond anything we have yet described. The first of these is where we simply imitate a note we hear.

This is quite wonderful enough, for it means the beautiful working together of the cells in the hearing center of the brain with the cells of that part of the brain which gives orders to the muscles of the voice-box.

THE MYSTERY OF THE WRITING AND SINGING OF MUSIC

But now take the second case, where a singer sings aloud the notes of a piece of music that he has never seen before. What is it that he imitates now? What is it that guides him? We can only say that the singer imitates, or realizes, his idea of a certain sound that he has in his mind, but what and where the idea really is, and how the singer can do what he does, no one can say, for we are here in the realm of the mind—the most mysterious of all things, and it baffles us utterly.

Lastly, we have the case of the composer sitting down with a pencil and a sheet of paper, and creating music "out of his head" for other people to sing and play. Some of the greatest music ever written—music which has made miserable people happy, and cowardly people brave, and frivolous people solemn, and will do so to the end of time—was written by a man named Beethoven many years after he had become stone deaf. He never heard a note of the greatest and most wonderful part of the music that he wrote; and yet, in his mind's ear, he heard it better than anyone has ever heard it since, or he could not have created it.



In these pictures we see the positions taken by the tongue and lips when different vowels are pronounced. The position of the larynx remains the same, the different sounds being produced by the changed position of the resonators, or cavities above the larynx. The vowels shown are A, as in father, E, and U.

TALKING AND SINGING

WE know how the larynx, or voice box, the musical instrument which we all possess, produces notes of any particular pitch that we desire. But though singing is very delightful and pleasing, and though many books might be written upon the voice box and its use in singing, speaking is really much more important than singing, and therefore it is necessary to study speaking from the point of view of the machinery by which it is done.

We have already learned about the wonderful center in the brain where words and the meaning of them are stored, and we understand that everything else depends upon the orders given there, but now we must go on to study the machinery by which those orders are carried out. The voice box is, of course, the central part of this machinery, but it is not all; and, indeed, everyone knows, who has whispered, that it is possible to speak without the voice box at all.

There is one point which has been greatly discussed by many thinkers, and which we must mention first. We know that we ourselves both speak and sing, and when we observe the birds, we find that they sing, but do not speak. The question is: Did singing or speaking come first? And there is a difference of opinion on this matter. A great Frenchman, named Diderot, at the end of the eighteenth century, and Herbert Spencer, many years after, supposed that singing came later than speaking. Their argument was that, after learning merely to speak, the time came when men wanted to make their speech more effective and thrilling and moving, and so they sang the words instead of only speaking them. So on this theory speech came first, and song is a sort of speech with more effect added to it by the addition of music.

But against these great opinions there is another great opinion—that of Charles Darwin. For many years he studied the expressions of feeling in man and in the lower animals. He found, as he thought, that many of the lower animals, especially the birds, sing of set purpose, so to speak, and perhaps sing very beautifully. He supposed that the special reason for the song of animals was to call each other and to please each other. Now, on this view, song came first and speech afterwards with man, and that is what Darwin maintained.

This is a subject which one writer has specially tried to study, and what he thinks is that in the case of mankind speech and song have arisen together. They are really two varieties of the same thing, which is expression by means of the voice. The argument of Diderot and Spencer that speech came first and song afterwards is, not supported by the fact that when we observe the growth of very small children, we can see the beginnings of speech and of singing growing up at one and the same time in them; nor is there any reason at all why this should not be the case. However this may be—and it is at least an interesting subject to think about—let us now go on to study what happens when we speak.

WHY IT IS THAT WE USE DIFFERENT NOTES IN SPEAKING

First of all, let us discover what is the difference between singing and speaking. In both cases we produce sounds by means of the voice box, except in whispering; in both cases these sounds are musical notes—that is to say, the waves which form them are regular; in both cases there are changes of pitch.

No one speaks with his voice all the time on the same note, even in the shortest sentence. We raise the voice sometimes, we lower it at other times, as we go along, and we convey a great deal by the way in which we do this; so much so, that children or foreigners, who do not understand the words we are saying, may learn a great deal from the pitch of the notes we speak in.

Even a dog or a horse will learn much from our voices in the same way. If anyone doubts that we use a number of different notes when we speak, let him get someone to say a sentence all on the same note, without raising his voice or lowering it. The Greek word for one is monos, and so, when something is spoken or sung all on the same note, we say that it is a monotone, and thus we get the word monotonous.

HOW WE ARE ABLE TO PUT COLOR INTO OUR VOICES

We could scarcely live with anyone who spoke in a really monotonous voice. Also, we use different loudnesses when we speak, and, apart from the actual note we are speaking on, we use different kinds of what is often called color in our voices. We speak to a child in a more tender tone than we speak to a car conductor, though we may speak more loudly to the child than to him. There are many different shades of expression which we can put into the same words spoken on the same notes and with the same loudness.

Now, the reason why it has been necessary to go so carefully into this is that we want to find out the difference between speaking and singing, and the first thing we find is that in all real points the singer does no more than the speaker does. He uses a variety of notes, he uses a variety of force, he uses a variety of colors. Both singers and speakers use a variety of rhythm and speed.

But, nevertheless, no one will say that speaking and singing are the same, and everyone knows what it is to hear someone speaking in a singsong voice. There is a common English word which has a very interesting history that bears on this point. It is the word cant. We say that a thing is cant or that a person is canting when we mean that he is professing high ideas that he does not really believe. The word comes from the Latin canto, I sing. Cant and chant are really the same word, and we might as well say that a person is chanting as that he is canting.

WHAT HAPPENS WHEN ANYBODY SPEAKS IN A SING-SONG WAY

The explanation is that at a very interesting time in history there were certain people, having very strict views on many things, who had the habit of speaking in a sing-song way. When they spoke they rather chanted. Their enemies said that they did not believe what they professed, and so the word cant, which really means singing, came to mean insincerity.

Now let us ask what it is that happens when a person, who was speaking in the ordinary way, speaks in a sing-song way, or actually sings. What happens is that he now produces notes which have fixed regular intervals between them, like the notes on a piano. When we speak we do not use the fixed musical intervals of pitch, but slide the voice up and down, without taking any notice of the fixed intervals of music at all. It is true, also, that as a rule, when we speak, we may keep our voice within the limits of, perhaps, half an octave or less, while when we sing we may range over a couple of octaves or more. But though this is evident directly we think about it, it is not the real difference between speaking and singing, which is that in singing we use only notes with fixed intervals between them, while in speaking we let our voice rest just where we please. If we think of a violin, we can, perhaps, understand this better. A player gets definite notes on the violin, such as the notes that are on the piano, by placing his fingers firmly on the strings at fixed intervals.

One of the great problems for the player is to get his fingers always at exactly the right places on the string. Now, when we sing, it is as if we were using just those intervals, only that, as we have seen, we do not get our notes by the violin player's method, but by tightening or loosening our vocal cords. If we do not use these intervals when we sing, people say that we are singing out of tune, and go out of the room as quickly as possible, and we are only asked to sing by people who have never heard us sing before.

WHY DIFFERENT PEOPLE HAVE DIFFERENT KINDS OF VOICES

But the violinist can also move his bow across a string and make it sound, while, at the same time, instead of stopping the string at certain intervals, he slides a finger right along the string. So, as the string gets gradually longer or shorter, he produces a series of notes—thousands in number really—which cannot be imitated on the piano. Now, our vocal cords can have any tightness or slackness, and so it is possible for us to pitch our voices, as we speak, at any point we like, just as if the violinist were to stop moving his finger at any point along the string of his instrument.

One of the great differences between voices is in the person's choice of the notes he speaks on. It might be supposed that if one did not sing, it would be all the same what notes one spoke on; but we all know that there are people to whose speaking it is a real musical delight to listen. It may be noticed sometimes that well-trained singers who sing quite well, but are not really musical, speak unmusically, and everyone knows cases of people who do not sing at all, but who have most beautiful speaking voices. To people with sensitive ears there is scarcely a greater delight in life than to be surrounded by people with beautiful speaking voices, and one of the reasons why we ought to study this question here is that we are running a grave risk today of losing the beauty of our speaking voices, and for several reasons.

THE GREAT CARE THAT SHOULD BE TAKEN OF THE VOICE IN LARGE FAMILIES

One reason is simply the way in which we crowd together. It is probably safe to say that more pleasant speaking voices come from small families than from large ones. If we are one of twelve children, and we want to be heard—well, we are rather apt to discover which is the most piercing tone we can produce, and then, perhaps, we use that all the rest of our life. People should take great care of their children's voices in this respect, especially when there are many children, and they all want to speak at once and be heard.

Perhaps it would be a good rule to listen first to the one who spoke most nicely and quietly.

A person who speaks in a high-pitched, harsh tone—as if he scarcely expected to be heard, but meant to have a try—tells us something about himself and his surroundings. Contrast that with the woman who speaks in a voice rather low-pitched, quiet, and musical. In so doing, she almost tells us—does she not—that she is accustomed to live in surroundings of peace and quiet where people do not interrupt each other, where no one shouts, and that she, indeed, would rather not be heard at all than make distressing noises. In perhaps the most heart-breaking scene he ever wrote, Shakespeare makes poor King Lear say of his daughter Cordelia: "Her voice was ever soft, gentle, and low, an excellent thing in woman."

To some children who read these words, this may appear not very important; but if we wait until we are unhappy, or until we are ill, or until we have to live with one and the same person all our life, then we shall find out what a difference it makes to be surrounded by people with soft speaking voices.

THE GREAT VALUE OF CULTIVATING A SOFT AND GENTLE VOICE

There are doctors and there are nurses who are worth far more than others are to their patients, not because they are more skilful or more conscientious, but because they have the kind of voice that often goes halfway to making a sick person well.

Every year hundreds of thousands of dollars are spent on singing lessons and on listening to singers. That is all very well in its way, but it is a curious thing that so few of us trouble at all about speaking lessons or about making any conscious effort at all to speak nicely. Parents will cheerfully spend large sums of money on having their children taught to sing, and will, at the same time, allow those children to talk regularly in a way which would distress any dog.

We already know upon what the pitch of the voice depends, and we know, too, that a tone of any given pitch may have different shades of color, or quality. This is, at first, not easy to understand, but it becomes clear as we study sound.

WHY WE CAN SING THE DIFFERENT VOWELS ON THE SAME NOTE

The fact is, that when we speak or sing on a given note, that note is really a mixture of a large number of notes. The lowest of these is the principal one, and is the one we hear best. But mixed up with it there are several others, called over-tones, which color it and give it its quality.

Now, we all know that it is possible to speak or sing any of the vowels on the same note. When we read this, we should quietly say or sing *a*, *e*, *i*, *o*, *u* to ourselves on the same note—and, of course, these are by no means all the vowel sounds that there are. Now, if these are all on the same note, what makes the difference between them? The whole difference between the

vowels consists of a difference in the number and proportion and comparative loudness of the over-tones. When we sing *a*, *e* on the same note, the difference is that when we make the *e* we do something which alters the over-tones that made *a;* and so, again, when we change the tone to *o* or to *ah*, or to any other.

If we carefully notice when we do this, we shall feel that something is happening inside our mouths. We are moving our throat in a different way; we change the position and the shape of the tongue, or, in some cases—as when we change the sound to *o*—we move the lips.

How we can make different sounds by moving the voice organs

In all these cases the larynx is unchanged, and the vocal cords are just doing what they did at first; but we are altering the shape of the spaces above the larynx—the resonators, as they are called—and so the over-tones are changed, and, instead of the particular set of over-tones which we have agreed to call *a*, there comes another which we have agreed to call *e*, and so on.

Children learn to make these sounds by imitation. That, by the way, is no explanation of how it is done, but still it is done. Now, youth is the time for learning, and afterwards not only is it difficult to learn new things, but also it is difficult to unlearn what we learned in youth. Different languages have different vowel sounds. Probably, on the whole, none of them is more difficult to learn to pronounce than any of the others. The question is really at what time in our lives we are asked to do so.

Every nation calls the sounds of the words of every other nation jaw-breaking for this reason. In English, for instance, we do not have the vowel sounds represented by the German ü or *ue;* nor has our *o* exactly the same sound as the Italian *o*. So we find it very difficult to make those sounds when we try to speak those languages, and, as a rule, we do not make them rightly. We may talk very good German or Italian, but the German or the Italian knows very well that these are not the languages we learned from the cradle.

Why a foreigner can never speak English correctly

In just the same way, a foreigner may use English far more correctly and wisely than we do ourselves, but though he lives half a century in America, and though he may be a very musical person, yet he will not make his vowel sounds quite correctly. The lesson of this is to teach us how marvelously delicate are the tiny movements of tongue and throat and cheeks and lips which decide the difference between *ham* as we say it, and *ham* as a German, speaking English, says it.

Another of the consequences of the fact that children learn by imitation is that if people, as children, have unfortunately heard the vowel sounds not quite rightly made, it is hard work, and perhaps impossible, for them ever afterwards to get them quite rightly. Now, to make the vowel sounds properly is a mark of having a delicate ear, and of having been surrounded by people who rather cared about these things, and so, though a man may speak beautifully and be a wicked man, or talk with a "shocking accent," as we say, and be a hero, it is worth while, perhaps, to pay more attention to this matter than many of us do. The number of possible vowel sounds is almost endless, for every possible position of the parts of the body concerned in speech will alter, by affecting the over-tones, the sound produced by the vocal

cords, and so each of these positions will correspond to a different vowel sound. But, as we know very well, speech consists not only of vowel sounds, but also of consonants, like *b*, *c*, *d*, *f*, *g*, and so on, and of these, also, there are a very large number.

THE DIFFERENCE BETWEEN A VOWEL SOUND AND A CONSONANT SOUND

The first thing for us to learn is, what makes the difference between a vowel and a consonant, and there is no doubt at all as to the answer. The difference between a vowel and a consonant is the difference between a musical note and a noise—that is to say, the difference between a series of regular sound waves and an irregular disturbance of the air. All the vowels are musical notes; to be more accurate, they are blends of many musical notes —the principal one and its over-tones. Now, *i* and *o* are just as much musical notes as *a* or *ah;* but if, instead of saying *ah*, we say *ark*, we are using a consonant, and it takes very little time to prove that we are now making a sound which is not a musical note at all, but a noise. There are many proofs of this.

For instance, the ear tells us the difference in pleasantness between a language full of harsh consonants, such as German, and a "liquid" language, as we say, like Italian, where two consonants of different kinds are scarcely ever allowed to be next to each other, and where the most is made of the vowels. In general, the higher the proportion of vowels to consonants in a language, the more musical we call it.

SOME SOUNDS THAT NOBODY IS ABLE TO SING

Again, we know that it is possible to sing a vowel, and though we may sustain the note for many seconds, we are all the time quite certainly producing the sound of that particular vowel—if we sing properly. But no one can sing a consonant, because every consonant is really an interruption, and nothing else, to the musical tone produced by the larynx. We seem to sing the letter *m*, it is true; but, in fact, when we listen to ourselves, we find that, after the first instant, we are simply singing through our nose a note which is neither *m* nor anything else. This fact of the nature of consonants, as compared with vowels, is very important, both for the singer and the speaker, but in quite different ways, and everyone who speaks or sings knows the difference.

WHY A SINGER LIKES TO SING IN ITALIAN

The first business of the singer is to sing—that is to say, to make music. But the singer is, as a rule, asked to sing words, though sometimes he may be allowed to sing for a little while a mere vowel like *ah;* and words are made up of vowels and consonants—that is, of sounds which are themselves musical, and sounds which are the very opposite of musical; some very unmusical, like *s*, and some less so, like *l*.

Thus, for choice, the singer will use a language, such as Italian, where the proportion of vowels to consonants is high, and when the consonants *do* come in, which, of course, they must if what he says is to be understood, he makes a point of dealing with them very quickly. Let them be definitely uttered, so that the people may hear what is being sung; but let this be done very quickly, because they are noises interrupting the music—every one of them. When we begin to learn to sing, we are all liable to try to sing on the consonants, and the first thing we have to learn is to do the singing on the vowels, which alone can really be sung. It is interesting to note, by the way, that the air-waves

made in singing, and even in speaking, will throw scattered powder into patterns, and on an accompanying page are some pictures drawn by the human voice.

THE GREAT IMPORTANCE TO A SPEAKER OF PRONOUNCING HIS CONSONANTS WELL

To return to speaking, the first business of a speaker, as contrasted with a singer, is to be understood, and when we come to study the words of any language, we find that the differences between them are due more to consonants than to vowels. The rule for the speaker, therefore, is exactly the opposite of the rule for the singer. Whatever happens, he must make no mistake about his consonants. He must not drop his voice at the ends of sentences or at the ends of words. It may be just at the end of the word that the consonant comes which tells people what the word really is. The fortunate and rare speaker is he who manages to get his consonants clearly enough sounded so as to be understood, and yet is not compelled to sacrifice all the music of his vowels. Such a speaker is a delight to listen to, for he satisfies both needs of his audience—the need of pleasant sound and of understanding without effort.

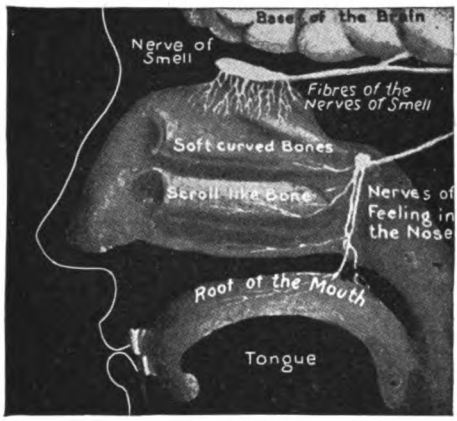
We do not need to study the consonants very long before we find, either by noticing what happens in ourselves or by looking at other people, that they can be classed. Certain parts of the organs of speech are specially used in making one set of consonants, and other parts in making other sets. For instance, we notice that we make *p*, *b*, and *m* with our lips, and so they are called the *labial* consonants, after the Latin word for lip. The first two we make by a little explosion of the lips, the difference between them being due not to the violence of the explosion, but to the quickness of it.

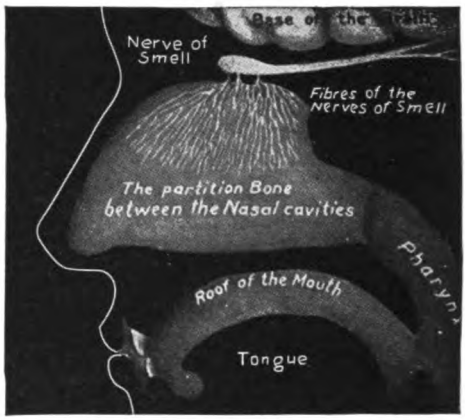
THE USE OF THE TONGUE AND THE TEETH IN PRONOUNCING OUR WORDS

Then we notice that the tongue is mainly used in the making of such vowels as *l* and *r*. There is certainly no doubt about the *r* if we roll it. Then there are certain consonants where there is no doubt that we use the teeth, as, for instance, *d* and *t*, and these are called dentals; and there are others, such as the sound *ng*, in which we evidently use the soft palate —that is, the back part of the roof of the mouth. So we call that a palatal consonant.

The larynx has nothing to do with the consonants, for, as we have seen, its business is to produce musical tones. We have also seen that the quality of sound produced decides the vowel, and that this is decided by the position of the tongue, the lips, and so on. It follows that if we allow air to pass up between the vocal cords, but without using them, we can still produce all the vowels and consonants; in other words, we can whisper, and that is what whispering is.

Thus, just as there are defects in speech due to defects in the machine, as, for instance, loss of the teeth, so also there are defects due to what controls the machine, and the chief of these is what we call stammering.



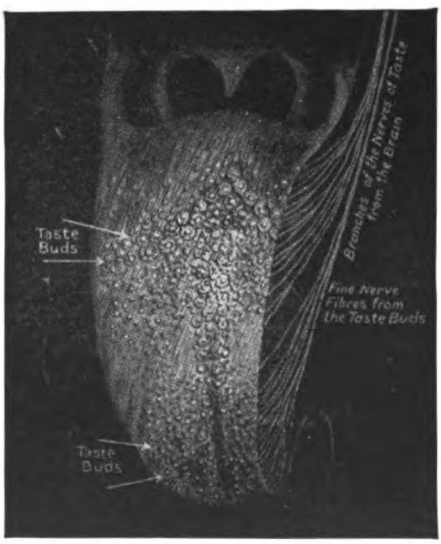


In the first of these pictures we see the outer side of the nose, with the nerves of smell and feeling, and the second picture shows the inner part of the nose, with the dividing plate of bone between the two nostrils.

SMELL AND TASTE

SMELL and taste are two senses which are of very trifling importance compared with hearing and vision, and we certainly need waste no time in troubling to ask how they may be taken care of; but they are, nevertheless, very interesting. These two senses are often called the chemical senses. Unlike hearing and vision, they do not depend upon waves, whether in the ether or in the air. We only smell or taste when the thing is actually touching the parts of the body which have this power; we see and hear at a distance, so to speak, but we cannot smell or taste at a distance. When we seem to smell at a distance, particles of the thing we are smelling have been carried through the air to the nose. This fact that smell and taste are so limited in their range makes them very inferior to hearing and vision.

Only a very small part of our knowledge of the world in which we live enters by these two gateways of knowledge—the senses of taste and smell. We know that these two senses are in great decline among the higher animals, and especially in mankind. While the senses of vision and hearing have become more important, the senses of taste and smell have become less so. These two senses are closely allied, and they very commonly work together. The taste of such a thing as cinnamon



In this picture of the tongue, the side has been removed to show how the nerves run from the sense organs, or buds of taste, to the brain. The taste buds are grouped at the back and tip of the tongue.

is very like its smell. A very large part of what we usually call taste is really smell. This is true not only of the aroma of coffee or tea, but also of the flavors of ordinary articles of diet. We can prove this for ourselves by noticing how differently our food seems to taste when the nose is thrown out of action by a bad cold.

We do not smell with the whole of our nose. Careful study with the microscope shows us exactly what part of the nose we do smell with. Roughly speaking, we may say that it is the roof of the nose and the upper third of it that we smell by.

The rest of the nose is lined by cells which have little projections that wave backwards and forwards and keep the channel clear; but the smell region of the nose is lined by special smell-cells, which correspond to the special cells that we found in the inner ear and in the retina. Each of the smell-cells is connected with a tiny nerve-fiber of its own. We find that this tiny nerve-fiber really grows out of the smell-cell, which is therefore a nerve-cell that has become changed. This is different from the rods and cones of the retina, or from the special cells in the inner ear, because they are not changed nerve-cells. The difference probably indicates to us how very ancient the sense of smell is, dating back to a time in the history of the body long before so many different cells had been made for so many different purposes as we find nowadays.

THE NERVES IN THE NOSE

The nose is supplied by two pairs of nerves coming from the brain. These two pairs of nerves are quite different in their duties. One pair has nothing to do with smell at all, but has to do with ordinary feelings in the nose. Anything tickling, or pricking, or hurting the nose affects these nerves; so does a thing like ammonia, which is irritating, besides having a smell. But this pair of nerves is not affected at all by scents that are not irritating.

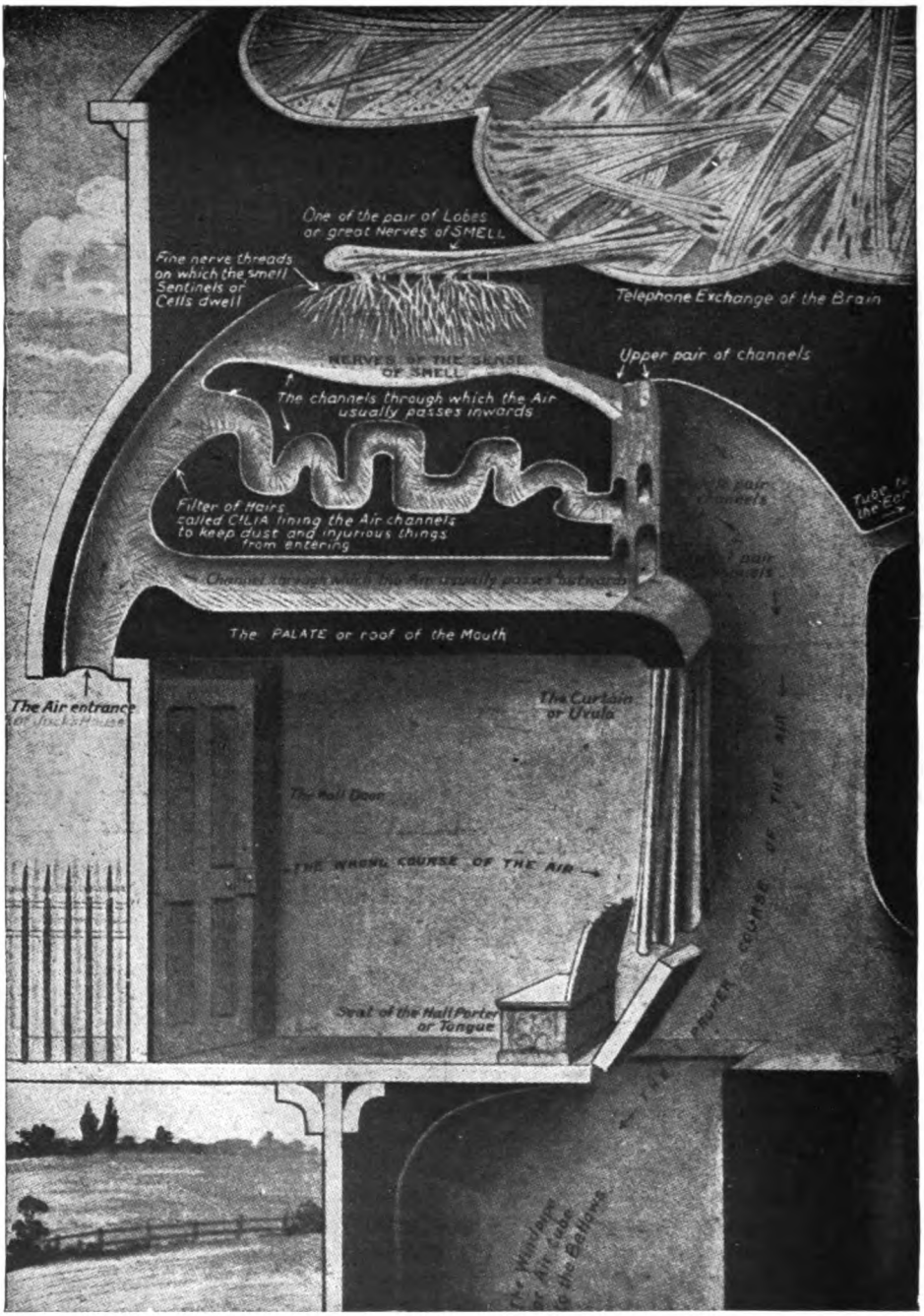
The other pair of nerves that come to the nose are the nerves of smell; they are known as the first pair of nerves, because they come off from the brain in front of any others. These nerves are apt to wear out, so to speak, in old age, so that old people lose, in some degree, their sense of smell, just as they often become deaf.

As everyone knows, there is an endless number of possible smells. Naturally, we wish to try to group them in the same manner that we group tastes, but it really is very difficult to classify smells in any way that people would agree upon. A very large number of oils found in plants have rather the same sort of smell, though, perhaps, it is not very easy to recognize any particular resemblance between such smells as turpentine and lavender.

FAMILY LIKENESS OF SMELLS

Still, on the whole, there is a general family likeness between the smells of plants and flowers; and, when we examine the oils that cause these smells, we find that they are related to each other in their chemical build. There are certain other groups of smells, such as the group to which carbolic acid belongs; and we can learn enough to see that there is a connection between the chemistry of a compound and its smell, but that is about all we can say. It is interesting to notice that electricity can stimulate our sense of smell as it can stimulate all our senses, and the sensation it causes is rather like the smell of phosphorus. It has also been shown that if we take a series of chemical substances which differ from one another in a regular way, their properties of smell also differ regularly.

WHY WE SHOULD BREATHE THROUGH THE NOSE



All sensible people breathe through the nose and not through the mouth, and this picture shows the reason why. The little hairs lining the channels of the nose act as a filter, keeping back dust and other harmful things, and the value of this filter is lost if we breathe through the mouth, where dust and germs have free entrance into the lungs. This picture shows also the little cells which enable us to smell, and the picture on page 138 shows more clearly the nerve of smell, seen at the top of this picture. When we smell a thing, small parts of it break away and touch the cells which live on the nerve of smell, and these cells can detect a particle of musk that weighs only a thirty-millionth of a grain, the sense of smell being more acute even than the eye aided by the microscope.

For instance, there is a long series of chemical substances beginning with marsh-gas. This has no smell—a very unfortunate fact for miners. The next member of the marsh-gas series has a faint smell, and farther on in the list the smells become very strong. It is also noticed that the things which have the most smell are the things, as a rule, which weigh heaviest.

Sir William Ramsay advanced a theory about smell, more than a quarter of a century ago, which is probably nearer the truth than anything else we can say. He thought that the power of exciting smell increases with the size of the molecules of a substance, provided, of course, that it is a liquid, or a gas, and not solid. Hydrogen, oxygen, and nitrogen have no smell, probably because their molecules are too small.

WHAT SMELL DEPENDS UPON AND WHAT TASTE DOES NOT DEPEND UPON

The first member of the series of alcohols has no smell; the next, which has a larger molecule, has a faint smell; and the still heavier alcohols have very decided smells. All this is very far from fully explaining to us what happens when we smell.

It is interesting to notice that sneezing cannot be excited through the nerves of smell, though it can be excited through the nerves of ordinary feeling in the nose, and through the nerves of sight. Lastly, it is noticed in the case of all the senses, more or less, that they are aroused by differences outside them, and soon take much less notice of what excited them very much at first, if it remains the same.

This is more striking, perhaps, in the case of smell than in that of any other sense. We have all noticed how quickly we cease to be aware of a smell which at first was perhaps very unpleasant.

TASTE

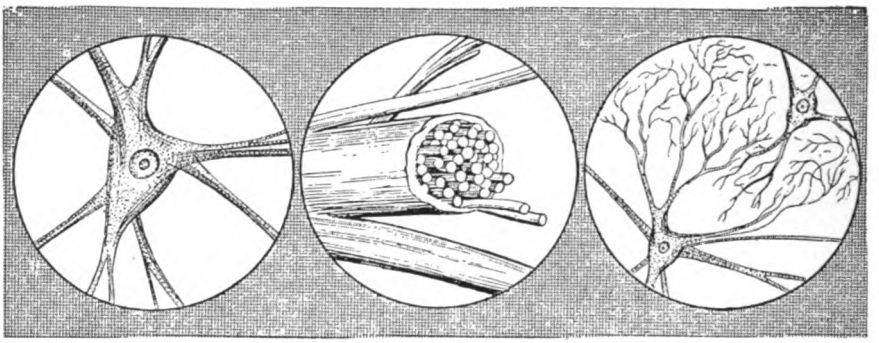
The sense of taste resides mainly in the tongue, but does not depend alone on the tongue. The special cells which are concerned with it, corresponding to the special cells found in the organs of the other senses, may also be discovered on the lower surface of the soft palate, and scattered over part of the throat in front of the tonsils on each side. A person who has lost his tongue does not entirely lose his sense of taste.

As in other cases, special nerve-fibers run to the cells of taste, which are most rich on the back part of the tongue, along the upper part of the edge of the tongue, and its tip. Taste is much less acute on the front part of the surface of the tongue. We can notice this especially if we place a quinine powder there and then swallow it.

Tastes can be classified much better than smells. Most of them come under the headings of bitter, sweet, acid, alkaline, and salt. The last three of these are probably not pure tastes, but mixtures of taste and ordinary feeling, so they can become painful when they are very strong. But bitter and sweet are probably pure tastes, and, however strong, and unpleasant, they can never cause such pain as the others do.

If things are to be tasted, they must be dissolved in a liquid.

With great labor and difficulty, the nerve-fibers that have to do with taste have been traced from the tongue, palate, and throat to the brain. The curious thing is that there are not separate nerves of taste as there are nerves of smell, vision, and hearing; but the special nerve-fibers of taste run along in other nerves which have nothing to do with taste, and they do so in a most extraordinarily complicated way.



In the left-hand picture, showing a nerve-cell magnified, we see the nucleus and nerve-fibers. These fibers may intertwine with those of another cell, as seen in the right-hand picture, but they never unite. The middle picture shows a bundle of nerve-fibers in their sheath, with smaller bundles branching off.

THE FOREST OF NERVES WITHIN US

IF we feel gently at the back of the elbow, rather towards the inner side, we find a thing that feels like a sort of cord, and if we squeeze it or knock it accidentally, we discover that it is what we call the "funny-bone." It is a nerve, and therefore belongs to the most marvelous of all marvelous things. If we take a nerve and look at it, we find that it is just a cord made up of tiny threads which are called fibers. It is these fibers that are the real nerves. The big cord is simply a bundle of them bound together into a larger cord.

A nerve-fiber is a thing which is probably not to be found anywhere in the vegetable world, but these things begin to appear quite low in the scale of the animal world, and their importance and number become greater and greater as we ascend. There is no part of the body that has not nerves supplied to it, and there is no part of the body that does not suffer in some way or another if the nerves running to it be damaged or cut.

When we examine a nerve-fiber, we find that it is a very long thread, usually surrounded by a sheath or coat which contains a quantity of a special kind of fat. There are a great many points of view from which we can think of a nerve as if it were an electrical wire, and the sheath may be regarded as what is called an insulator—a thing to prevent the current that flows in the nerve from leaking outside it. It is very interesting to take a modern electrical cable such as men lay in the Atlantic Ocean, and to cut it across and see what it looks like; and then to take a good-sized nerve and cut it across and magnify it so as to compare it with the cut cable. We see at once that men have found it useful to make their cables on exactly the same principle as nerves are made, with bundles of fibers big and little, all carefully insulated from each other. Of course, the nerve is much more wonderful, but the general principles of the way in which the nerve-fibers are packed together, and the way in which each is sheathed so as to prevent any leakage of its precious current, are really just the same as in the case of the cable.

When we excite our "funny-bone," as we call it, by hitting it, we feel a tingling in our fingers. We have excited the fibers which carry feeling along the nerve from the fingers to the brain. In other cases when we

excite a nerve, muscles will twitch. We have excited fibers which carry orders along the nerve from the brain to those muscles. This shows that nerves carry something, and may do so in either direction, from the brain, or to the brain. The nerve-fiber is therefore a conductor. It is just like the wires in the cable. They do not make messages, but they carry them. What runs along the wire will run in either direction. Any particular nerve-fiber carries what it carries only in one direction; however, it has been proven that it *may* carry messages in either direction.

THE LIVING NERVE THAT CARRIES MESSAGES THROUGH OUR BODIES

The wire carries an electrical current. As long as the wire is not broken, and is properly insulated, the current will run. The wire is not alive, and, though we by no means understand what happens in it, yet it has not about it the mystery which we find when we look at a nerve.

For the noteworthy thing about a nerve is that it will only carry what it carries when it is alive. We can remove a piece of nerve from an animal that has been killed, and can study it in various ways. If we keep it moist with water containing a little salt, and if we keep it warm enough, it will live for quite a long time, and as long as it is alive things that disturb one end of it will send something through it. But when it dies it will no more carry messages than a piece of string will.

What makes the difference between life and death in the nerve we cannot understand until some day, perhaps, we shall learn what life is. We can see no change under the microscope to account for this difference, for we have to kill the nerve in order to look at it under the microscope.

THE MYSTERY OF THE NERVE CURRENT THAT NO MAN CAN UNDERSTAND

The thing that runs along the nerve we call a nerve-current, or a nervous current. Current simply means something that runs, and that is really almost all we know about it. It is not the same as anything else in the world; it directly depends upon the life of the nerve, as we have seen. It is not electricity. Curious changes are produced in a nerve when a nerve-current runs along it, and among these changes is the production of electrical currents of various kinds, which have been long and carefully studied. These show that an electrical change has been produced in the nerve when a nerve-current runs along it, and the study of these electrical changes may help us to understand the nerve, but it is a very great and serious mistake to suppose that the nerve-current is electrical.

Electrical currents in a cable or anywhere else move at a wholly different speed from that of a nerve-current. Nerve-currents have been measured again and again, and they travel at rates which, compared with the movement of electricity, are very slow. The rate of a nerve-current seems to be about the same as the rate at which a baseball can be thrown. An electrical current is hundreds of thousands of times faster.

Nothing seems to be used up in a nerve when it conveys a current, any more than in the case of a telegraph wire. So we cannot make a nerve tired. As long as it remains alive, it will go on sending currents as often as we choose to start them in it. The case of a nerve-cell is very different.

THE NERVE-CELLS UPON WHICH ALL OUR FEELINGS DEPEND

We have only been talking about conductors, remember. We have, so to speak, taken a piece of one of these

conductors, just as if one took a piece out of a cable, and we have studied that. But if we wished really to understand telegraphy, we should have to study what is at the ends of the cable, and that applies to the case of the nerve, too. We found that we could excite a nerve by hitting it against something, as when we hit our funny-bone, or by pinching it; and there are dozens of other ways, as, for instance, by giving one end of it an electrical shock, dropping chemicals on it, and so on. But, of course, that is not what happens naturally in our bodies. We must find where the nerve comes from.

Every nerve-fiber grows out of a nerve-cell. It is part of that cell. It is only the servant of the cell, carrying orders from it or messages to it. The real thing, where the greatest mystery lies, and upon which everything depends, is the nerve-cell. When we study the development of the body, we find that every nerve grows out of the cell that it belongs to; we find also that, if a nerve be cut across the part which is next the cell is unhurt but the part which is separated from the cell invariably dies. We find also that, if a nerve cell is destroyed or poisoned, the nerve-fiber running out from it invariably dies, and if the nerve-cell has been actually killed, that nerve-fiber can never recover.

So these "cable wires" are not merely alive, but they are created by living cells, of which, indeed, they are living parts. That is one of the marvels which make a cable a very simple thing indeed compared with a nerve.

THE DENSE FOREST OF NERVES THAT GROWS UP IN OUR BODY

A nerve-cell may have only one fiber coming from it, or it may have several. Very frequently, for certain purposes, we find nerve-cells which have one fiber coming out from each end of them. The fibers from any nerve-cell are very often found going to meet the fibers from another nerve-cell. Suppose, then, we can trace a nerve-fiber from a cell somewhere in the brain, for instance, and we find that it meets another fiber from another cell, perhaps at some other place in the brain. It is interesting to know whether the two fibers run into each other. Careful study shows that the fibers never run into each other. At their extreme ends they break up into tiny little fingers, so to speak, and the fingers of the two fibers will interlace; but they never run into each other. If we study parts of the brain where many nerve-cells and nerve-fibers exist together, we find, as someone has said, that it is very like a dense forest. Their leaves and branches intermingle with each other in the closest possible way; but they never actually join. We shall never find a leaf that belongs to two trees.

WHAT THE SIMPLE BRAIN OF A BEE OR WASP IS LIKE

All this is very important, because it teaches us that just as a gas is made of atoms, just as the body as a whole is made of cells, so the nervous system is made up of true units which are also cells, and though these cells are of a very peculiar kind and produce fibers which may run right away from the body of the cell for inches or even feet, yet each cell remains a true unit.

In the very lowest animals that have nerve-cells and nerves, the number is very few, and the arrangement very simple. They are usually arranged merely to carry feeling from the outside of the animal to its inside. But as we ascend the scale, nerve-cells and nerves get more numerous, and often, for convenience, numbers of them get bunched together into little balls,

each of which is a sort of nervous center, perhaps somewhat like a telephone exchange.

When these collections of nerve-cells become very large, they make a thing that we can only call a brain, and such are the brains of a bee or a wasp, for instance. The whole arrangement of nerve-cells and nerve-fibers is called a nervous system.

When the first backbones came into existence, there also came into existence a number of new nerve-cells and nerve-fibers, and the central home of this new nervous system was inside the backbone. The old nervous system, such as the insects have, remained, and communications were established between it and the new nervous system.

How the brain sends and receives messages through the nerves

In all animals that have backbones, both these nervous systems are found, and we may say very roughly that while the old one, which we ourselves inherit from the days before backbones, looks after the interior life of the body, it is the new nervous system that is the instrument of the mind. At its upper end, the long tube inside the backbone opens out, as we know, into the hollow skull; and in the same way the nervous matter which is found in the backbone, and which we call the spinal cord, becomes enlarged, and forms what we call the brain.

The brain and the spinal cord form what is often called the central nervous system. Through holes in the skull and through openings in the backbone run nerves which connect the central nervous system with every part of the body, and every part of the body with the central nervous system.

It seems quite clear that, whether we take the group of cells that forms a mere hair or any other of the least important parts of the body, we always find that it has a perfect double connection with the central nervous system. The brain, or the spinal cord, or both, can send to it messages upon which its life depends, and it, on the other hand, can send messages to them.

When we come to study the central nervous system, we find it so arranged by means of this double connection that every tiniest part of the body is really in true communication, when necessary, with every other part of the body without exception. It is this amazing fact that helps to explain how the body becomes a whole in spite of the infinite variety and number of its parts. In no city on earth, however rich in telephones, and speaking tubes, and telegraphs, and post-offices, and messenger boys, is there any arrangement a thousandth part as wonderful as the arrangement by which the nervous system connects all the parts of the city of Mansoul, as John Bunyan called it.

The forest of nerves running to and from every part of our body

We have already learned what is necessary regarding nerves. If we simply understand that the lining of the heart, the wall of a vein, the base of a nail, every muscle-fiber, and all other parts of the body are doubly connected by nerves with the central nervous system, we do not need to inquire how and where these nerves run; though, of course, the doctor has to spend long months and years in studying this. We must devote ourselves now to the central nervous system, and especially the brain.

The central nervous system consists, in a way, of a number of levels, or layers, and, as the bodies of animals have become more and more wonderful, new layers have been piled up on the older ones, and each new layer is the master of all the layers below it.

It is in this way that we can come to understand the working of the brain and the spinal cord. The spinal cord is very old; its business nowadays is to attend to things which are beneath the notice of the brain, as, for instance, the movements of the stomach and that kind of thing. It is a sort of highly trusted and responsible foreman in the house of man, and, like other foremen, it not only looks after a great many small matters on its own account, so as not to trouble the master, but it is also the master's means of communication. As a rule, the master gives orders to the foreman, and then he does the rest.

THE SPINAL CORD THAT ACTS AS FOREMAN TO THE BRAIN

On the other hand, tradespeople and so forth, when they have anything to say, do not go to the master, but interview the foreman, and he takes the message to the master; so also does the spinal cord. When we close our hands, the brain, which gave the order, did not speak directly to the muscles of the hand. No nerve-fibers run directly from the brain to those muscles, but nerve-fibers do run from the brain to the spinal cord, which is the foreman. They give orders to certain nerve-cells in the spinal cord, and from those nerve-cells there run fibers which go to the muscles of the hand.

If we cut across the spinal cord, and take a very thin slice of it and stain it with various dyes that will show up the way in which it is made, we find that its structure exactly corresponds with its duties. We find in it fibers and cells. Some of these fibers are running to the brain, some from the brain; a great many of them arise from cells in the spinal cord, and run to other parts of the spinal cord, and end there. If, for a moment, we think of the spinal cord as a huge exchange, or place of business, then these fibers are like the private wires that do not come from or go to the outer world, but connect one part of the place of business with another.

THE WONDERFUL BOX IN WHICH THE CENTRAL NERVOUS SYSTEM IS KEPT

The usefulness of the spinal cord very largely depends upon the proper working of these beautiful arrangements which keep every part of it informed as to what every other part of it is doing, and enable different parts of it to act in harmony when they so require—which is practically always.

The picture on another page shows us the central nervous system as it appears when taken out of the wonderful box—the skull and backbone—which exists to protect it. We see how, at its upper end, the spinal cord becomes slightly thicker so as to form what we might call a bulb. That, indeed, is one of the names for this part of the brain. It contains the group of nerve-cells which controls our breathing, and the destruction of which means instant death; also another group of nerve-cells which controls the heart; another group which controls the size of the blood-vessels; another for the acts of sucking and swallowing; another which controls perspiration; and there are probably more. All of these are contained in a little portion of nervous tissue that is just about the size of the end of one's thumb. Above the bulb, things become very complicated. If we had to begin with the study of the grown-up human brain, we should never find the key to it; but if we study the brain as it develops, and if we study the brain in animals, the thing becomes clear. We see quite plainly that what is the lower underneath part of the brain in us, all huddled and squeezed together and completely poked out of sight by

something else that has grown over it, is the old brain, the first brain that ever was, so to speak. It contains countless numbers of nerve-cells, arranged in groups with different duties. It is mostly concerned with movements of the body, and in lower animals it is also the place where hearing and seeing and feeling are done. In ourselves we know that some of these senses have become so delicate and wonderful that they require new machinery, and the old centers which were good enough for lower animals are now, in us, only half-way houses towards the new brain.

Behind the old brain there is a large and important piece of nervous tissue which has a name that really means the little brain. It is called the *cerebellum*. This cerebellum, we have found, gets larger and larger in higher forms of life, but we cannot find that it has anything to do with feeling. We do not hear or see there, it starts no movements, and certainly the will and the powers of thinking do not live there. We find that it is a great instrument for making the body do what we want. The power of balancing the body lives there. A drunken man staggers because he has poisoned his cerebellum. Also the balanced use of the muscles for complicated and delicate actions, like painting or playing the violin, depends upon the control of the cerebellum. It may be thought that these duties are not very exalted, and we may wonder, therefore, why the cerebellum should get bigger as we ascend in the scale of life. But we have already learned that the one thing in the world that we can do is to move things, our bodies and things outside them. Through this power of movement, and only through it, our minds can live and act. So it is very important that our control of movement should be as fine as possible.

It can be proved that in the main line of ascent of life, more and more delicacy and accuracy of movement have always appeared. Part of the history of progress is the replacing of strength by skill. Babies and small children are very clumsy, and as they gradually become more skilful, this means mainly that the cerebellum is developing and getting the powers which it has in grown-up people. In proportion to size of the whole body, the clumsy, stupid animals are those that have a very small cerebellum. The best example of this is one of the most stupid of all the higher animals, the hippopotamus. We can understand that when we catch anything, following it with our eyes, and then getting our hands or our mouth to it, we must be using the cerebellum. The hippopotamus has practically no idea of catching at all. It takes a very long time to even see things that it likes, and if they get into a corner, it is so clumsy that it has not sense enough to use either its feet or its mouth to get them out again.

THE LITTLE BRAIN OF THE GREAT HIPPOPOTAMUS

All this depends upon the smallness of its brain, and especially of its cerebellum. It is reckoned that the brain of the hippopotamus weighs about the same as that of the horse, the weight of whose body is only one-fifth as great. It has been proved over and over again that, in the history of life, success has always gone more and more to brains, to skill as against strength, to mind as against muscle. The hippopotamus is a remarkable instance of an animal that has survived through long ages from the days when brains in general were much smaller than they are now, and the explanation is not to be found in its huge size and

strength, but entirely in its mode of life. Its size and strength could never have saved it against better brains.

In the past there have been far bigger and stronger animals than even the hippopotamus, and they have all died out, but the hippopotamus is content to live upon grass and similar plants growing in rivers. It has its nostrils right on the very top of its face, so to speak, and so it can lie with its whole body in the water, and just leave its nostrils above to breathe by. In this way it saves itself by hiding, and still lives on, while the other stronger and wiser animals have completely disappeared from the earth.

As we pass upwards in the scale of life, we find that with the growth of the cerebellum, and the development of skill, there comes a time when even the mouth, that dogs and cats and lions and sea-lions are so quick in using, is not a good enough instrument for the clever brain.

THE USE OF THE ARMS WHICH GIVES MAN HIS GREAT POWER

Something even better is required, and so, in the main line of ascent, we find that the animals called lemurs, which are a very humble and ancient kind of monkey, use their hands a little for grasping as well as walking, though they prefer to use their mouths, as anyone can see who feeds them at the Zoo. But when we reach the highest apes, we see that they find and examine, and lift their food with their hands, and then carry it to their mouths. The arms, then, limbs which for countless millions of years have been used by all sorts of different animals for the same purposes as the hind legs, and for no other, now come to have special purposes of their own, and every finger becomes precious.

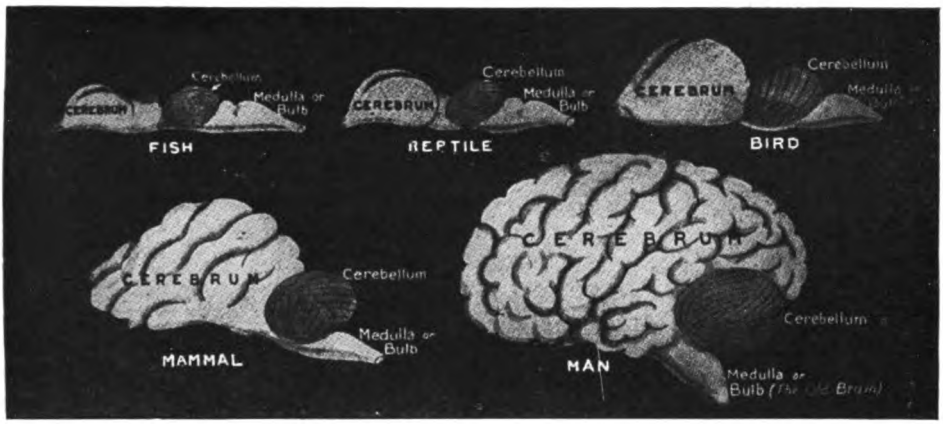
Cleverer even than the half-erect apes is man, who, after crawling babyhood is past, frees his fore limbs forever from the duty of locomotion, and learns how to use every one of his fingers separately, as with the typewriter or the piano. There has therefore been an immense development of skill in man—though mere strength has decidedly fallen off—and with it there has necessarily gone a great development of the cerebellum.

This is very interesting, because it helps us not only to understand the brain, but also to understand children. Children belong to a race that lives in the world by its ingenuity of all kinds, and so they like to practice their skill. This is why children love games of skill, and this especially is why, ever since children existed, they were fond of balls.

WHY IT IS RIGHT THAT BOYS AND GIRLS SHOULD PLAY

Of course, grown-up people do not like to have their windows broken; but still it is right and natural for children to play. What we call play, and stupidly think of as waste of time, is now known by wise people to be part of the necessary education of a child, if it is to reach the best possible for it in health of mind and body. Its play is really an essential part of the work of the child.

It is a pity that many children in America have nowhere to play but the street, no one to teach them good games, and no one to care what becomes of them, but the time will likely come when all children will be able to have happy playtimes.

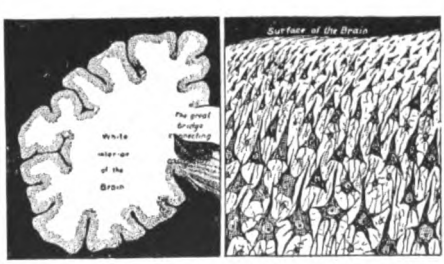


These diagrams enable us to compare a man's brain with the brains of other creatures. The size of each is drawn in proportion to the size of the creature's body, and we see that man's brain is very large.

MYSTERY OF THE BRAIN

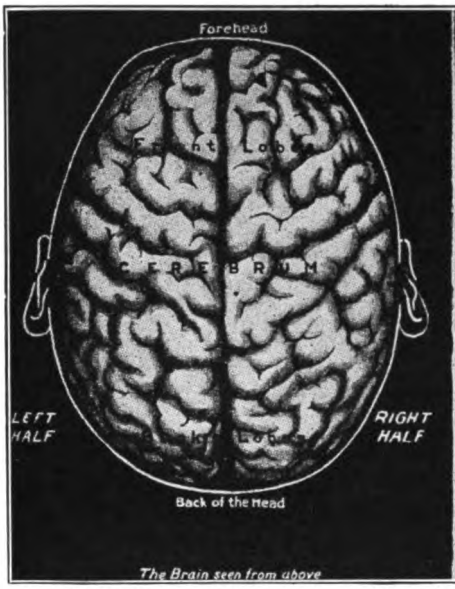
WE now know that, in ourselves, the highest and most important part of the nervous system is what may be called the new brain. One of our illustrations shows what it looks like when viewed from above, and the first thing we notice is that there is nothing else to be seen but the new brain. It is so large, and has grown out so far in all directions, that the whole of the older part of the nervous system is hidden underneath it. In an ordinary way, when we talk about a man's brain or brains, it is entirely of this new brain that we are thinking. The proper name for it is cerebrum. The word cerebellum, which we already know, really means litt'e cerebrum.

Now, our first glance at the cerebrum shows us that it is a double organ. It has a right half and a left half. These two are just like each other, though it is probable that in right-handed people the left half, and in left-handed people the right half, is very slightly larger. We have, therefore, in a sense, two brains, just as we have two arms; for our bodies are built upon the principle of there being two halves corresponding to each other. If we slightly separate the two halves of the cerebrum, and look down between them, we see a mass of white nervous tissue which is evidently running across from one side to the other. This is a great bridge between the two halves of the brain, by which they are made to work and act as one. When we look at the surface of the brain, we see at once that it is very much folded; all over it the surface has been turned inwards into deep valleys. These vary in depth and length, but on the whole they form a very definite pattern,



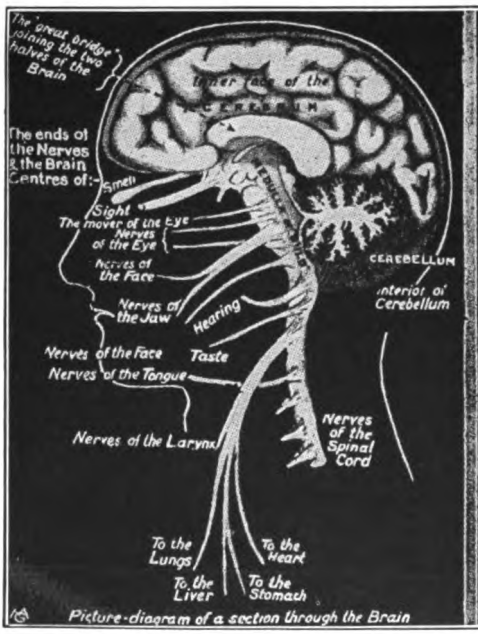
The left-hand picture shows a section across one side of the brain, and we see by the shaded border the thickness of the gray matter of the brain, as compared with the white nerve-fibers. On the right is a tiny speck of the gray matter, magnified a hundred times, showing the pyramid-like cells and the fibers.

THE INSIDE AND OUTSIDE OF OUR BRAINS

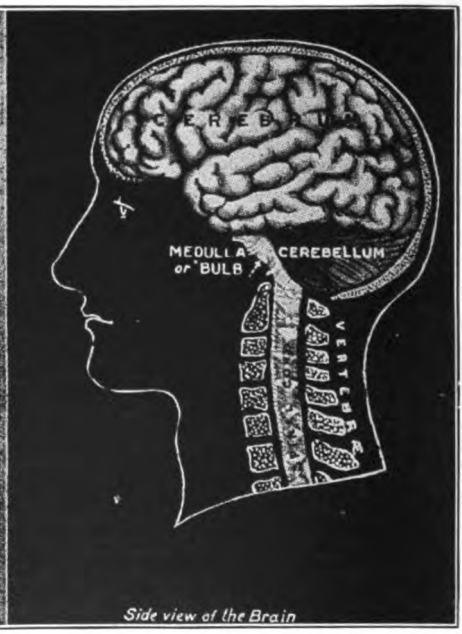


In this picture we see what our brain would look like if the top of our skull could be lifted like a lid. The cerebrum, or new brain, is the part by which we reason out things, and it completely covers the cerebellum.

Here we are looking up at the underneath part of the brain, and see the nerve-endings of the various senses and of the vital organs, all cut off short, except the nerve of smell, which is shown ending in a bulb.



This section of the brain, as seen from the side, should be compared carefully with the picture of the brain seen from underneath. In both pictures, the nerves are shown in the order in which they leave the bulb, or old brain.



In this side-view of the brain, we see the proportion of the skull occupied by the brain. The convolutions, or folds, are shown, and the position of the brain in relation to the spinal cord and the backbone is easily seen.

which is the same on both sides of the brain, and the main lines of which are the same in all human beings. All the folds and the spaces between them have special names.

First let us understand what the folding means. The use of it is that it permits what is really the surface of the brain to be enormously increased, without requiring it to take up more room. Now the surface of the brain, as we shall see, is the all-important part. Brains have been growing bigger in the animal world generally for countless ages past. This means that there has been a great deal more room required to house the brain in, and so skulls have been getting larger. The size of the skull of man, compared with the size of his whole body, is simply gigantic. But though this is so, it very feebly indicates what the huge growth of man's brain has been, simply because the brain has grown far more quickly than the skull, as life has ascended, and has deeply tucked in its surface, here and there, as it went on growing, until there is now as much, or perhaps considerably more, of the surface of the brain tucked away than shows on the outside. In general, the higher the type of brain, the more is its surface folded. We can show this whether we trace the brain upward in different kinds of animals, or whether we compare different human brains with one another. As animals have become more and more clever, and have trusted more and more to brain and skill, rather than to size and strength, the surface of the brain has become more folded, and people who study the subject can tell in a moment, by looking at the surface of the brain alone, whether it belongs to one of the older kinds of animals or to one of the higher animals that have more lately appeared on the earth.

THE MANY FOLDS IN THE BRAINS OF VERY TALENTED MEN

A great many brains of famous men have been examined; many great men, indeed, have left orders that their brains should be examined for the advance of knowledge. As a general rule, these brains are found to be very highly folded. The contrast is very great between them and the brains of, say such an humble type of mankind as the Bushman of South Africa. Of course, this means that if we could unfold all the brains in question, and stretch out their surfaces quite flat, the wiser brains would be the brains with the biggest surfaces.

The size of the skull, its shape and the bumps on it, can tell us absolutely nothing whatever as to how much the brain is folded; still less as to what we shall find when we examine more closely what the foldings are made of. There is, on the whole, and in a very rough way, some correspondence between the size of the skull and the size of the brain inside it. But, for one thing, skulls vary in thickness; and, for another, no one can possibly tell what it is that is making up the size of the brain. Even if all skulls were the same thickness, and even if bumps corresponded to the brain, which they never do, the brain inside might be large because certain spaces inside it were swollen with fluid, or it might be large but have a comparatively smooth surface. It is quite easy to understand that a well-packed brain, which will go into a much smaller skull than another, may yet, if unfolded, have a far greater surface.

WHY THE SKULL CAN TELL US NOTHING ABOUT THE BRAIN

About a hundred years ago, when practically nothing was known about the brain, men thought that, by feeling and measuring the skull, they could learn about the brain, and so tell

the character of the person to whom it belonged. Our modern knowledge of the brain has taught us that it is hopeless to expect this, simply because the things that really matter do not affect the skull at all. If a surgical operation were performed, so that a considerable portion of the brain were exposed and could be seen, then we might, perhaps, make a very rough guess as to what the person was like; but as we should have to judge how far we were right entirely by what we knew of the person in the ordinary way, it is difficult to see where the advantage of such an operation would come in.

Now, we must understand why it is that the surface of the brain matters so much. When we cut through the cerebrum of any of the higher animals, we find at once that it consists of an outside layer, which is gray in color, and an inside layer, which is white. This gray layer, which covers the entire brain, always dips down and up again wherever the brain is folded. There would be no meaning in the folds if it did not. It is often called the mantle, that is, something which is stretched all over the outside of the cerebrum.

THE REAL BRAIN OF MAN THAT IS THE MOST WONDERFUL THING WE KNOW

At no part whatever of either half of the brain, whether we look at the part it rests upon or in the depths of any of the folds, do we find this wonderful mantle lacking. It is the real brain, and, as we find it in mankind, it is the most wonderful thing of which we have any knowledge. It owes its gray color, and all its meaning and wonder, to the fact that it is mainly made up, not of nerve-fibers, but of nerve cells. The rest of the brain is made up of nerve-fibers or nerves, and these give it a white appearance, like that of an ordinary nerve in the arm or the leg; but the gray mantle contains only comparatively few nerve fibers, which connect its different parts in some degree.

HOW THE REAL BRAIN IS MADE UP OF THOUSANDS OF MILLIONS OF CELLS

What really makes up the gray mantle is thousands of millions of nerve-cells. These nerve-cells are vastly more wonderful even than those we find in the spinal cord, or those which are in the medulla and control our breathing, for they have to do with thinking, not to mention seeing and hearing, and so on.

Only a very few years ago, it used simply to be taught that when we take a very thin layer of this gray mantle, and look at it under the microscope, we see five layers of cells in it; one on the very surface of the brain, and so on, until the fifth lies next the white matter inside the brain. We can recognize these five layers because the cells in the different layers differ rather from one another in their size and shape and number. But now we can go much farther than that. It is, in general, true that we find about five layers of cells in any part of the gray mantle that we care to examine, but we also find that the cells differ very definitely in different parts of the brain. Also, if we carefully examine corresponding parts of the brain in large numbers of animals of quite different kinds, we find that the same arrangement of cells occurs in corresponding places.

THE LIKENESS BETWEEN THE BRAIN OF A MAN AND THE BRAIN OF AN ANIMAL

If a microscope slide containing a large number of cells shaped like pyramids and arranged in a certain way were shown a man who had studied the subject, he very likely could not be sure what animal the brain has belonged to, but he could say in a moment that that was the

part of the brain which the animal used when it wished to move its muscles.

Again, if he saw certain curious little groups of cells lying not very far from the surface of the brain, he would say, without hesitation, "that comes from the part of the brain the animal smelled with." No one has the least idea yet what this particular group of nerve-cells has to do with smelling, but we always find them in the smell part of the brain, and nowhere else. This is equally true of creatures like the dog, in whom that part of the brain is large, and of creatures like ourselves, in whom it is comparatively small.

The parts of the brain which have to do with sight and with hearing are just as definite in their structure, so that it is vastly easier to tell that we are looking at something taken from the vision part of the brain than to tell what animal it was taken from.

The whole of the surface of the brain has been mapped out now very completely.

WHY A MAN'S BRAIN IS BETTER THAN AN ANIMAL'S

Now, when we have carefully learned to map out the various brain centers, as they are called, for the motion of muscles, for feeling from the skin, for sight, hearing, taste, and smell, we find that still the greater part of the whole surface of the brain is actually untouched. It is almost as if the greater part of the surface of the brain had no duties. We cannot find that it has anything to do with any of the duties that we can think of.

Now, when we begin to examine the brains of other animals, it soon becomes possible to take, shall we say, twenty different brains, and arrange them in an ascending order, beginning with the brain of some simpler kind of animal, as, for instance, a rabbit, and ending with the brain of man. If we do this we find a very wonderful thing. It is that the lower we go down, the nearer together in the brain are the different special centers which we have already found in the brain of man.

Indeed, when we go low enough, the whole brain practically consists of these various centers—for motion, and seeing, and so on—all lying right up next to each other. They make the brain. But to look at it the other way, as brains improve and get bigger, what happens is, not that these various centers get bigger, but that they become gradually separated from each other by the growth of new parts of the brain which appear and come to lie between the old centers. This process goes on and on, until at last in mankind, and only in mankind, it has reached the stage at which the various special centers, which long ago lay all together and were the brain, have become mere patches that lie here and there on the surface of man's huge brain.

What, then, is the meaning and the duty of these great new places that have come into existence, and to which the growth in the size of the brain is really due? When we question them, they are silent; indeed, they have been called the silent areas. We shall surely get some help in our studies if we can trace the course of the nerve-fibers that run out from the nerve-cells in these particular areas.

THE WONDERFUL FIBERS THAT LINK ALL OUR SENSES TOGETHER

As regards the special centers, we find that the fibers from the cells in them run just where we should expect. The fibers from the seeing centers run straight to the eye, the fibers from the hearing center are connected with the ear, the fibers from the center for movement run down into the spinal

cord and are connected with the nerves that go to the muscles. These facts, of course, help to give us the key to the duties of these centers. If now we can find where the nerves run to from the silent areas, we shall guess what these areas really do, and it must be something very important indeed, because, whatever it is, it seems to explain the real difference between clever animals and stupid ones, high ones and low ones.

We find, then, that these fibers from the silent areas run in every possible direction, but in very definite groups and ways, to the other centers of the brain. What they do is to associate one part of the brain with another. I think we can understand that if there were no such things, then, though an animal might see very well, nothing that it saw would connect itself in that animal's mind with anything that it had heard, or felt, or smelled. Now, when we come to study the way in which we act, the way in which we put two and two together; when we notice how one thing makes us think of another thing, we begin to understand how it is that the association fibers make all the difference in the world between a high brain and a low one.

WHERE A MAN'S BRAIN DIFFERS FROM THE BRAIN OF A DOG

If we compare the spinal cord or the medulla of a dog with that of a man, there is nothing worth mentioning to choose between them. If we compare the new brain of a dog with that of a man, we find a difference, but it is one which mainly consists in association fibers and cells. If we compare the vision center of a dog with that of a man, we find the two in the same part of the brain in each case, and with the same special type of cells.

The difference, however, is that the gray mantle in the case of man is much thicker; and when we come to inquire into what makes it thicker, we find that it contains a vastly greater number of fibers, which are running to it from other parts of the brain, and of new cells, which have nothing to do with seeing itself, but which send fibers out from the seeing center to all the other parts of the brain. In general, then, we may say that the differences between a high brain and a low brain are, first, that in the various special centers the gray mantle is much thicker in the high brain, because it is crammed with new association cells; and second, that in the high brain the special centers are forced apart by the growth in between them of new parts of the brain, which do not mean the invention of any new kinds of senses, but mean bringing all the parts of the brain into closer relation and connection with one another.

SOME OF OUR SENSES THAT ARE MORE NOBLE THAN OTHERS

There are one or two very interesting exceptions to this rule, and they have a meaning. It must have struck all of us, if we ever think of our senses, that some of them are more noble than others. We agree, do we not, that it is a more dignified thing to enjoy a picture than to enjoy a chocolate? Someone may say: "Well, in either case, we are simply using one of our senses; why is not one as good as another?" But when we suppose that vision and hearing are more noble than taste and smell, we are quite right, and the reason is that they are more human. They reach a higher development in us than in any other creature, while so far as concerns smell, about which a great deal has been learned, it is probable that our brains are far inferior to those of almost any other creature that has a brain at all.

THE SENSE OF SMELL, THAT IS WEAK IN MAN AND STRONG IN ANIMALS

If we study the smell part of the brain in different kinds of animals, we find that smell reached its perfection ages ago, when vision and hearing scarcely existed. But such a sense as vision is far finer than smell, because not only does it act at very great distances, but it gives us a thousand times more information than smell can possibly give.

Therefore, part of the history of progress in the world of life has been that sight has improved and has largely taken the place of smell. This is most marked in ourselves. The dog is a very high kind of animal, and belongs to an order which ranks next to the monkeys themselves, and we all know how splendid the dog's scent may be. But in our own brains the part which corresponds to smell has shrunk to almost nothing; it is, indeed, so small that it took a very long time to find where it was; while the vision part of the brain has become huge.

The great growth of the back of the cerebrum in man is due to the importance of vision to him, for it is the extreme back part of the cerebrum, on both sides, that we see with. Our real eyes are at the back of our heads. We have already learned that the cerebellum is very large in us; but even though this is so, the vision part of the cerebrum has grown so enormously that the cerebellum is completely hidden from our sight by the cerebrum, when we look down upon the brain from above.

THE DIFFERENCE BETWEEN ONE KIND OF SENSE AND ANOTHER

It might be supposed that there is something wrong here, because many animals, such as birds of prey, have far keener sight than man has. That, indeed, is so; but are we right in supposing that the mere keenness of a sense is the highest thing about it? Not at all. The point is the extent to which we can use the information that the sense gives us, and the way it is linked up with every other part of our minds. The vulture can see a speck on the desert sand at a tremendous distance, but will the vulture enjoy a fine picture, or feel itself made humble and pure before a sunset? Of course, when we ask questions like this, we see at once what it is that really makes a sense high. No known animal has in the vision center of its brain anything like the depth and variety of structure that we have in ours. This is the great fact for us to remember about the place where the seeing is really done.

We have seen that smell and taste are comparatively unimportant in man, and in both cases there was long argument, and much work had to be done, before we could be sure in what part of the brain these two senses really lived. It might be supposed that the sense of touch would not be greatly developed in man, and that perhaps it is rather falling into the background, like smell and taste. This is a very great error, however. The most intelligent of all birds is the parrot. We notice this not only in its power of imitating sounds, but in many other ways.

WHY THE SENSE OF TOUCH IS CALLED THE MOTHER OF ALL THE SENSES

Now, it is an interesting fact that the parrot has a far more delicate sense of touch than any other bird. It really has quite a good notion of using its claws as fingers. It has the idea of stroking and feeling what a thing is like as we say. Now it is not just a chance that the most intelligent bird is the bird with the best sense of touch. It is what we should expect. The sense of touch is the mother of all the senses, in a way, and good

education of the sense of touch is the foundation of all good education.

Probably some of those who read this will disbelieve it, but all the great students of the mind know that it is perfectly true, and have been saying so for scores of years. We are learning to understand what games mean for children, because they train the sense of touch and teach it how to work with sight; and we are also beginning to learn that drawing and carpentry, and the sort of things that children do in kindergarten, are invaluable foundations of education. There was a time when it was thought that anything good for a child must be something that it disliked, and that anything it liked must be mere amusement. Who would think that the real meaning of the word school is leisure—doing what we feel inclined to do? Yet so it is.

Now there is nothing we notice more positively about an intelligent child, and any child is intelligent until foolish grown-up people begin to interfere, than that it loves using its fingers. Of course it gets into mischief, but the child that never got into mischief, and never touched things it ought not to have touched, was never yet taught to read. There are such children, but they can be taught nothing, and we call them imbecile.

Whatever happens, the healthy child must constantly use its sense of touch; it must forever be fingering things. Now we find that the touch part of man's brain is simply magnificent. It is the delicacy and the variety of his sense of touch and, far more than that, it is the marvelous way in which man's sense of touch is connected with all his other senses, that accounts for our skill, which is almost the most wonderful thing about us as compared with any other creature. Not in a thousand years could any other creature but man be taught, for instance, to read with the fingers, even if that creature had a brain that could understand.

THE GREAT BRAIN PUZZLE THAT BAFFLED MEN FOR YEARS

For a long time it was a great puzzle to find the touch center in man's brain. It lay, so to speak, under our very eyes; but we never thought of looking for it there. A very large area of the gray mantle on each side of the brain is the center for voluntary movement, and it is here that the will of man gives its orders. For many years we knew this, and called it the motor center; and when we were looking for the center of the touch sense we never thought of looking there. But now we have found that the center for will and movement is the center for touch. The two lie mixed up together, and the connection between them is the closest of all connections in the nervous system.

THE WONDERFUL NERVES OF HEARING THAT ENABLE US TO ENJOY MUSIC

The sense of hearing lives low down on the side of the brain. As we all know, this sense of hearing has led to the possibility of music and all that that means. As in the case of seeing, of course there must be good machinery outside the brain if a sense is to develop, and the history of hearing, like the history of vision, is partly the history of the ear and the history of the eye. Here, however, we must merely learn that the hearing center of the brain is very large in mankind, and that when we examine the cells contained in it we find a state of things that exactly compares with what we found in the case of vision. It may be that some animals can hear sounds so slight that we cannot hear them.

"Thought," as Expressed by Three Famous Artists

The first of these pictures is from Michaelangelo's statue of Lorenzo de Medici, the second is from a painting by Sir John Millais, and the third is from a statue by a great French sculptor, Auguste Rodin.

HOW WE THINK

THE putting of things together in the mind, or association, as it is called, is the beginning of all the powers of which we are most proud; but though the usual name for it is the association of ideas, yet it does not apply only to ideas, but to everything that can enter the mind—a scent, a pain, a tone of voice, and thousands of other things that cannot be called ideas at all.

We know that there is a stage beyond seeing, and that is perceiving, and the proper name for a thing perceived is a percept. Like everything else, except mere sensation itself, perception depends upon memory. The case of a puzzle picture, where we look for a long time and at last perceive a face, is a good instance of the difference between seeing and perceiving, and the same applies to hearing sounds and recognizing them as a tune.

But these things that we perceive and make percepts are not ideas; they are simply a certain set of sensations put together and made into a whole. Perception is a great advance upon sensation, no doubt, but there is something better still, and the proper name for that is conception, or conceiving, as when we say, "I conceive that the stars must all be suns." That was the great idea, or conception, of Giordano Bruno, and it is evidently something beyond the mere perceiving, or recognizing, that certain colors and shadows we see make a chair.

We have passed from the mere level of things looked at, or sounds heard, to the region of thinking. Here is an idea, or a concept—a thought. Two memories have been put together in the mind and connected, or held together, by it in a certain way. Previously there were in the mind the memories of certain percepts; first, the stars, and secondly, the sun. But the mind performed the great act of conceiving; it associated, or put together, the two percepts, the stars and the sun, and it made a new and different thing—the thought that the stars are suns.

For thousands of years men had not only seen the stars and the sun, but had perceived them, and had carried in their minds clear memories of the stars and the sun, so that they could recognize them when they saw them again. But not until the mind of Bruno said "The stars are suns and the sun is a star" had anyone performed this great association of ideas,

to use the old name. This instance we have chosen is a great one, but we perform little associations of ideas every day, whenever we think at all. A great instance has purposely been chosen, because what we are trying to understand is the building up of the mind, and such a case as this helps us to realize the orderly stages of the mind's wonderful ascent from the mere sensation of seeing up to one of the greatest ideas in the world. Let us just observe for ourselves how the stages follow upon one another.

How a child's mind is gradually built up

John Locke said that there is nothing in the mind except what was first in the senses, and that everything which comes to be in the mind is built up out of sensations and reflections upon them. Now, this is true, even in such a tremendous idea in astronomy as that the stars are suns. This begins with mere sensation. The mind begins its existence in babyhood and childhood without any inborn ideas of any kind. Its first experiences are mere sensations. The eye, as we know, is made from a part of the brain which has come forward outside the skull—"The brain comes out to see," as has been said. The eyes are turned upwards, and certain impressions of light are gained. These are mere sensations.

If there were no such thing as memory, they might be repeated every night during a lifetime, and nothing would come of it. But living matter remembers.

So, beginning with sensation and with the necessary help of memory, we pass to the stage of perception where the points of light seen one night are more than seen, for they are perceived to be the same as the points of light that have been seen on former nights.

Real thinking is putting things together in the mind

Percepts are remembered just as sensations are, and so we may go about with the percepts in our mind of the stars and the sun. Then one man singled out from the rest puts the two percepts together, and so makes a concept by this process of conception, or thought, and says the stars are suns. This teaches us the slow and necessary order in which the mind is built and grows, and the dependence of its highest deeds upon its humblest deeds. It is also a good instance of the truth that all thinking is association of ideas. The word conceive means "to take together;" the word associate means "to make companions;" and all thinking is putting things together—making companions of them, making a relation between them.

To some extent we all do this without effort or intention, but beyond a certain point we are very apt not to trouble about it. The point where we stop the process is the point at which our interest ends. Thinking is not a thing that happens to us, but a thing that we do, and in all doing a motive power has to come from somewhere. The motive power in this great doing of the mind, which we call thinking, is interest. Here we come to the key of one of the great differences between men, and, if the study of the association of ideas taught us nothing else, it would still be well worth while to study for this.

The secret of success in all great thinkers

We are right to admire the "kings of thought," but we are very wrong in our notions of what makes them great. It is true that in certain departments there are very special powers which one brain has and another has not; this is true of mathematics, for instance, and

of music. But, apart from that, there is nothing more certain than that most of the great thoughts, and most of the great discoveries of mankind, might have been thought or made by anyone if they had been interested enough.

The secret of most of the great deeds done by the minds of men, in the way of pure thought or association of ideas, has been the great difference, not in the way in which the great minds associate, but in the fact of interest and patience leading them to go on thinking, endlessly revolving the ideas in their minds, and at last finding out the truth.

For, of course, associations of ideas may be false or true, or they may be merely fanciful, not pretending to be true, as when we say the moon is made of green cheese. But the greatest business of the human mind in its power of association is the discovery of truth, and we ought to have a right notion in our heads of what we mean by truth.

We may think of our mind as a kind of mirror in which the outside world is reflected. Outside then there are things and the reflection of things in our minds ought to correspond to the things as they are. Things outside and thoughts inside ought duly to reflect each other. Very often they do not. Our image of the outside world is distorted and twisted, or there are huge gaps. But, to some extent, our thoughts, the associations of our ideas, do genuinely correspond to the associations of things in the outside world; and then we can say that our thoughts are true.

THE THINGS THAT MAKE A MAN A GREAT THINKER

Anyone can associate any ideas; there is no difficulty about that. We may say the stars are night-lights, and a fancy like that may have some good in it as a fancy; but the great object of our minds is to make our thoughts genuinely correspond to things.

The great thinker is he who not only associates ideas, but makes the associations correspond to the associations in nature. The virtue and value of the thought that the stars are suns is that that relation between the two in our minds is the relation between them in nature. The reflection of things in the mirror of our minds is so far perfect.

If association is an act of the mind requiring power to do it, if it is vastly important as it is because right thinking goes a long way towards right doing, and if interest is the great motive which makes the mind think, then, certainly, it is our business to find out how far we can help and foster this interest in our minds, and also to find out whether one kind of interest differs greatly from another in its value for this purpose.

HOW WE MAY HELP OURSELVES TO BECOME REAL THINKERS

In the first place it is certainly possible for us to foster interest in our own minds and in the minds of other people, and there are few more useful tasks than that of the people who go about trying to open other people's eyes, as we say, so that they shall see the interest of things and thereby start thinking about them.

There are false or doubtful kinds of interest, as well as good ones. A man may be interested simply in making money, and the machinery of association in his mind will work, in consequence, with astonishing skill and rapidity; or a boy may be interested only in passing an examination, and so his machinery of association works hard for a time at something or other, and after the examination he seldom or never thinks of it again.

The blame is not his but that of the system that makes a victim of him. Worst of all, perhaps, in its results, is the kind of interest which sets men studying things only in order to defeat someone else, or to prove that they are right, or to make a success for the party or the class or the church to which they belong against some other party or class or church. This kind of interest is extremely powerful and very general and, according to the universal laws of the mind, it produces its due result. Unfortunately interest of this kind and interest in money are the driving power of most of the work of association or thinking that is done in the world.

THE HARM OF LETTING OUR THINKING BE GUIDED BY WRONG INTERESTS

If association done under interests of this kind resulted in the discovery of truth, that would be good; but, as a rule, it does not. Interest in the success of our party or our class or our religion, or of the people who have paid us to think and argue, destroys the true working of association of thinking in two distinct ways—both are disastrous. One of them is obvious, and the other is not.

The obvious one is that it is to our interest now to make the worse appear the better reason. We do not now make all the possible associations in our minds until we find the one which seems the truest, but we simply make the associations which best suit our case, and then we try to persuade other people that they are true. Things are so complicated that most men, if they think a little—and their interest sees to it that they do—can make the worse appear the better reason, and so associations are formed which are false. This may benefit the person or the class or the country or the party, but in the long run it must injure mankind. We must believe that truth is far more worth while than falsehood, or else we had better stop thinking at all. But there is the second less obvious way in which the false kinds of interest lead men astray. In the last case men deliberately deceive other people, but in this case they unconsciously deceive themselves. This is because the whole process of association can be upset and changed by feeling. Long ago this was quite forgotten by men of science.

THE WAY IN WHICH OUR FEELING AFFECTS OUR THINKING

There was a time when men thought that the intelligence, or intellect—the part which knows and thinks—was practically the whole of the mind. They took no notice of feeling, and they thought that our deeds proceeded only from the results of what we thought. It is very strange how men could have thought this, for everyone knows how largely our feelings determine our deeds.

But today we do not make the mistake of supposing that the intellect is the whole of the mind, and so we are prepared to understand how much the intellect is affected by other parts of the mind. Thinking, or association, is a kind of doing, and we have just said that doing is largely determined by feeling. When we feel angry we are apt to kick, or hit, and so on.

Now, what is true of other more obvious kinds of doing is also true of that very wonderful, though less obvious, kind of doing which is called thinking. What we feel often decides what we think. We want to win, for money or for glory or for spite; we are fighting another country and we want to prove that we are right; or we are fighting for our class or our church against people who dress rather differently, or who arrange the service rather differently in their places of

worship. We fancy that we are seeking the truth, but we are not seeking the truth; and just for that reason we do not find it.

THE WRONGFULNESS OF BELIEVING ONLY WHAT WE WANT TO BELIEVE

This upsetting of the judgment by feeling so that as happens every day all over the world, men come to believe what they want to believe, is one of the most important facts in the life of mankind, and accounts for half the facts of human history. If we are at all sensible and watchful, we can soon notice for ourselves what happens, because it is apt to happen to every one of us; and we need not wait long for a chance of observing it. What we shall find is probably this: that somehow or other all the facts and ideas and memories which suit what we want to believe, or to prove or persuade other people stand out strongly in the foreground of our minds. We know that the secret of attention is interest, and these things which we want to believe interest us most, and so we attend to them most.

Unfortunately, we attend to them so much that we do not attend to the other facts and ideas which do not suit our case. But we cannot form associations unless we attend, and so the associations which we do form, and the arguments which we use, are all based upon the things we have attended to, the things that interested us most, the things that suited our case.

THE REASONS WHY MEN DO NOT ALWAYS SEARCH FOR TRUTH

We may be arguing with someone else who is interested to prove the opposite. Just as the points which favor us press up into our minds, so the points which favor his case press up into his. But really we do not listen to his arguments, and he does not listen to ours, and neither of us convinces the other.

This is the sort of thing that happens in politics, and most of the things men quarrel about. There is a certain amount of deliberate deception, but the great key to the differences of opinion which divide even intelligent men is self-deception, depending upon the way in which our processes of association are spoiled by our feelings and our interests.

This danger comes into everything, even into the discovery of truth. There are many reasons why it enters there also. It is not the discovery of truth, but trying to persuade people that we have discovered truth, that often leads to money or glory. Quite apart from that, when a man has said a thing, he likes to prove himself right and that, of course, is not quite the same as liking to find the truth.

Then there are motives like jealousy, or motives like trying to prove that something which is believed by our church or our class or the particular school to which we belong is right. All this only causes disaster. It means that a man, instead of looking at all the facts, looks only at some of them; it means that he sees the importance of facts that suit his case, and cannot see the importance of those which do not, and so he goes wrong.

But everywhere in all ages there are a few men who are real lovers of truth. They would rather give up their beliefs than believe what is untrue; they would rather believe the truth and be despised and hated than persuade men of something that is not true and be honored.

WHY A THINKER SHOULD BE INTERESTED ONLY IN SEEKING THE TRUTH

The success which in some measure always attends these people, so that, if their brains are of a high order, they become the great thinkers of the world, like Newton or Darwin, depends absolutely upon the quality of the interest

which drives them. We must have interest in order to make us think, or associate, but we must have the right kind of interest if we are to think rightly.

We can see, if we study the work of such a man as Darwin, exactly the way in which this interest in truth, and in truth only, keeps a thinker right. He is afraid of only one thing, and that is of going wrong. If his object were to prove anything in particular he would be more interested in one set of facts than in another, but as it is he is equally interested in all facts, because all facts lead equally to the truth. They do not all lead equally to his theory, perhaps, but that does not really matter—it is so much the worse for his theory, and so much the better for the truth.

THE MAN WHO TRIES TO FIND FACTS, AND THE MAN WHO TRIES TO PROVE A CASE

Darwin began with a theory which came into his head, and then he spent twenty years working at it. People say that he spent twenty years trying to prove it, but that is simply not the case. If we study Darwin's mind, and the lines of the work he did, we shall agree that it is nearer the truth to say that he spent twenty years trying to disprove his theory. Indeed, he was trying to prove or disprove nothing, but simply to find the truth.

The success of the successful lawyer is, of course, entirely different. His business is to win his case. He therefore lays all the emphasis on the facts which favor it, and purposely keeps in the background the facts which do not. He gets the verdict of the jury but that is not the method to follow if we wish to gain the verdict of no jury, not even of all mankind, but the verdict of Truth herself.

A WISE MAN WHO KNOWS LITTLE, AND A FOOLISH MAN WHO KNOWS MUCH

It is of no use to store things in the mind if we cannot recall the right things when they are wanted. But people who have not studied the mind constantly make this mistake. A man may be a walking encyclopedia, and yet be very foolish. His mind is crammed with facts, but he cannot associate them rightly; they do not suggest each other to him in their true relations, and so they are simply useless. Another man may have only one-thousandth part of the knowledge, but a thousand times more wisdom, because the facts in his mind are properly sorted and arranged and connected and classified and compared, or, in a word, the facts are associated.

HOW TO REMEMBER

We know the great difference between seeing and perceiving, and we must now consider the memory, without which there could be no real perceiving. It is just because memory makes perceiving and even higher things possible that its importance is so tremendous. If we could not remember, we should be nothing. Without memory there would be no recognizing, there would be no learning, no knowing. We are so accustomed to use this power of memory that, we think, we cannot realize what we should be without it. We see something coming along a road, far away, and then, after a while, we perceive that it is a human being. Later, by the dress, we can tell that it is a man and not a woman, but who it is we cannot tell. Finally, we find that it is someone we know. Here we see that the memory acts even in the simplest kinds of perceiving, and that it is worth while to devote some time to the study of it.

NOWADAYS, in dealing with such a great question as that of memory, we do not make the absurd mistake of trying to understand our memories without studying every kind of memory wherever we can find it; and the first great discovery we make is that, in some degree or other, memory is a property of every kind of living creature. Formerly it was said that memory was a property of every kind of nerve and nerve-cell, and that is perfectly true, but it is not the whole truth.

During late years men have studied the behavior of humble forms of plants, and of animals so simple and lowly that no nerves or nerve-cells are as yet developed in them. Yet even here, almost at the beginnings of life, long before there is the least shadowy hint of even the simplest kind of brain, we find some proofs of memory.

All living matter is called protoplasm, and it is a fact that memory is a property of all living protoplasm everywhere. No matter how simple creatures are, we find that their behavior can be made to change by changing their surroundings. This means that in some degree they remember; they act differently because something has occurred perhaps three times before, and the fourth time it occurs they do not behave exactly as they did the first time. What it is in living matter, whether of a nerve-cell or of any other kind of cell, that enables it to remember, we cannot say; neither can we say in advanced cases of memory, as when we remember an idea. But even in the humblest cases of memory, as where an animal behaves differently towards light because it is the second time and not the first time it has seen it, we can only guess what happens. The light the first time somehow made some kind of mark, as we might say, in the living cells, and altered them, so that the next time the light came they were different.

It is supposed by many people that living matter never forgets. When we say we forget, what we mean is simply that we cannot recall. But the thing we say we forget is still there in our mind, and when someone names it we recognize it; if we had really forgotten we should not recognize it.

But even where we cannot recall a thing for ourselves, and where we cannot recognize it when it is recalled for us by somebody else, it by no means follows that we have really forgotten. There are many cases on record where a man appears to have utterly forgotten, for instance, certain words of some language which he learned and spoke when he was a child; he cannot recall them, and they mean nothing to him when they are recalled; but he proves that they are still there in his mind when, perhaps, he is suffering from a very severe ill-

ness. His brain is greatly upset, and these words, which he may not have heard or used for fifty years, or more, come from his lips. Very likely they are used without any sense, and he does not know what they mean, but there they are. The brain has not really forgotten them.

THE DIFFERENCE BETWEEN REMEMBERING AND RECALLING

Such cases as these teach us that in all probability living matter does not forget, but, more than that, they show us that what we call memory is very far from being a simple, single thing. In what we call an ordinary act of memory there are three things involved. There is the pure remembering, with which we have not much more to do than a table has to do with remembering a dent made in it; there is the recognizing of what we remember; and there is the power of recalling. Everyone who has been asked at an examination, "What is this?" and who knows perfectly well that he has seen it a hundred times before, but cannot put a name to it, knows that memory is not such a simple thing as we sometimes suppose.

But in every act of memory the beginning of it is the making of an impression on the brain. No doubt this is a vastly different thing from making a dent on a table, but we do no harm if we think of it as if it were something like that; and, indeed, the only word which we can use to describe it, such as the word impression, which just means "pressing in," suggests a comparison of this kind. Now, as this is the beginning of all memory, it is very important for us to know how far and in what way we can improve this power of ours.

WHEN THE POWER OF THE MEMORY IS AT ITS BEST

We shall make nothing but mistakes unless we learn first to distinguish this part of memory from the other parts; and, secondly, to discover any natural changes in this power during the time that we grow from childhood to age. It is very likely that, on the whole, memory is at its greatest when we are young, and tends to diminish steadily as we grow old. There is an apparent exception to this, because at certain ages boys and girls seem to be able to learn poetry and many other things by heart with greater ease than they could have done a year or two before. But this is because the brain is, as it were, just being finished in its making. It is likely, on the whole, that after that the power of being impressed steadily diminishes.

This explains to us some facts about memory which seem peculiar. For instance, we know that, in a general way, we are more likely to remember things that have recently happened than things that happened long ago. This is probably only because the things that happened long ago are lower down in the mind, so to speak, and have been overlaid by many newer things.

WHY OLD PEOPLE REMEMBER BEST THE THINGS OF LONG AGO

Now we often find that old people instead of remembering the latest things best, remember them very badly; but, though they are doubtful about recent events, they remember quite clearly something that happened perhaps many years before. The explanation is that the newer impression was made on a brain that was losing its power of being impressed, but the older one was made on a young and very impressionable brain; and the passage of time has not destroyed the deep impressions made in youth.

When we compare different people, we find that there are differences between them in this quality of memory. It is supposed by nearly everybody

chat education accounts for these differences, and makes them. So one of the great objects of education is to "train the memory." But, if by training the memory we mean making the brain more impressionable than it is by nature, nothing can be more certain than that this was never yet done by any kind of education, and never will be.

To begin with, these differences between people are natural. The amount that a man remembers will, of course, depend upon the amount that he has tried to remember, and so his education is immensely important, because it largely means giving us opportunities for remembering. But that is an absolutely different thing from any effect in actually improving the power to remember, so far as this first part of memory is concerned.

THE ONLY EXCUSE FOR LEARNING A THING BY HEART

The differences between people in this respect are enormous, but they are natural differences, and we simply have to accept them as they are. Of course, they make a tremendous difference in our lives, because we have seen that memory is the basis of everything else; and though different kinds of memory are needed for different people—as for instance the painter, the engineer, and the musician —yet these differences in memory are the beginnings, at any rate, of the differences in what the people achieve.

It is quite certain, then, that the brain's natural power of being impressed cannot be increased by any of the methods which have been too long adopted for that purpose. There may be a good reason for learning by heart, simply because there are things which it is well to have in the mind, and which can be made to stick by repetition. But no kind of learning by heart increases the brain's power of retaining things. Learning by heart does not train the memory; it very often disgusts the mind and disheartens it from thinking.

The only possible defence for learning anything by heart is that the thing is worth knowing. There are plenty of such things, and the time will come when we shall carefully take children at just those ages when learning by heart is easiest, and deliberately use those years to put into their minds the best possible selection we can make of the things which everyone ought to know.

THE THINGS THAT WE MUST KNOW AND THE THINGS THAT WE SHOULD KNOW

There are things that people must know and there are things that they should know if possible. The number of these things is a million times greater than could be remembered by the wisest and most learned man that ever lived. We must therefore do our best for each child, and that best will mean the careful selection of the things it should learn and the using of the time when remembering is easiest. We must break up and vary the lessons so as to avoid fatigue, because when fatigue begins, memory ends. Though education cannot improve the natural memory, yet there are certain things which education, in the widest sense of the word, can do or fail to do. Whatever the brain is meant to be by nature, and whatever is in its power to become, yet the building and the health of its cells and nerves, and therefore the success of their duties, depend upon the supply of blood they receive, and upon their never being subjected to over-use.

What we call education, which is sometimes just the opposite of real education, very often means that we injure the brain and spoil the memory at the very time when we think we are training it. School hours are

often too long. Light, and especially air, may be defective. Foul air means foul blood, everywhere and always; and foul blood means that the brain also is being poisoned.

A HEALTHY OUTDOOR LIFE IS THE BEST AID TO MEMORY

Our great business, therefore, in taking care of our memories when we are young, is to lead healthy lives as much in the open air as possible; and no doubt we shall find that, in after years, for every one thing we remember that happened indoors when we were children, we shall remember two things that happened out-of-doors.

Next we have to consider the various special methods of impressing the memory. The first of these is the method of repetition. We all know that repetition helps us to remember, and, indeed, this method of going over a thing again and again is the one which has been most believed in since teaching began. This applies equally to our learning-memory and our doing-memory, as we recognize when we say that practice makes perfect. Now, so long as we clearly understand that repetition and learning by heart do no good to the memory itself, but merely help to impress it, we are quite right to use this method, and there are certain things well worth noticing.

THE BEST WAY OF REMEMBERING WHAT WE HAVE HEARD

One of the great methods of learning is to listen to something spoken and take notes of it. Now in such cases we notice that the two processes of listening and writing down and reading over result in much better remembering if they are close together. If we read our notes the same day as we take them down, we shall remember more a month hence than if we go over them a few days later. When the repetition comes close on the first impression, it is as if the iron were made hot by the first impression, and the second impression is more effective than if we wait for the first to cool.

Another most important fact is that one kind of repetition is very different from another, and this is one of the mistakes that almost all of us make. We may hear without "taking a thing in;" we may read or write a thing, or we may repeat it out loud, while our attention is somewhere else. In such cases all our labor is wasted, as certainly wasted for remembering the thing as it is wasted for "training the memory." It is no use trying to learn when we are tired or when we are feeling cold, thirsty or hungry.

WHY READING HELPS US TO REMEMBER BETTER THAN WRITING

It is worth noting that intelligent, careful, attentive reading of anything is a more effective kind of repetition than copying it out, though we should not suppose so. In copying out, as a rule, too much of our attention is devoted to the mechanical part of what we are doing, and so we are not really attending so well, though we seem to be working harder.

The secret of mere remembering lies, on the whole, more in attention than in anything else. It is most difficult to find out exactly what attention is, and exactly what happens when we attend. The difference between attending and not attending is probably that, when we are not attending, the disturbances that reach the brain from the outside world are scattered in all sorts of directions throughout the brain. The effects of them are almost wasted, because they scarcely go anywhere in particular; and it may be also that perhaps the most important parts of the brain, when we are not attending, are really not in action at all, so that the results of what is going on never reach them.

MEMORY TESTS ON THE BOOK OF OUR OWN LIFE

THE STORY OF THE EYE

What evidence have we that plants have eyes?

What insect possesses most powerful eyes?

Why does the house fly avoid a flame?

How are bees able to distinguish one flower from another?

In what respect is the vision of ants superior to ours?

In what respect does the eye of a backboned animal differ from that of an invertebrate?

What is the main purpose of the eyelids?

THE PARTS OF THE EYE

How does the cornea of the eye resemble and how differ from a curved piece of glass?

What purpose does the iris serve?

What determines the color of the iris?

In what respect is the lens of the eye superior to an artificial lens?

Why does a near-sighted person hold the book close to him?

What is the effect of age upon near-sightedness?

How is a cataract removed?

SEEING COLORS

What is light?

What relation exists between the numbers of ether vibrations required to produce the sensation of red and the number required to produce violet.

In what three ways do colors vary?

How many colors are there?

Name the three primary colors.

What is the cure for color-blindness?

What forms does color-blindness assume?

Why are red and green lights used for railroad signals?

THE MARVEL OF HEARING

How many senses have we?

What purposes are served by the outer ear?

Why can a dog judge better of the direction of a sound than a man?

How do we judge of the direction of a sound?

By what means is the canal of the ear kept clean?

To what is deafness in old age generally due?

What control have we over the intensity of sounds?

BALANCING THE BODY

What do you understand by the sense of balance?

What four different things aid us in preserving our balance?

How does a fish so easily preserve its balance?

Explain the connection between fish-gills and the semi-circular canals, ears and larynxes of higher animals?

Are the lower animals "dumb?"

What three duties does the larynx perform?

TALKING AND SINGING

In speech are all the words given in the same key?

Give the derivation of "monotone."

Give the derivation of "cant."

What is the essential distinction between speech and song?

What is meant by a "musical voice?"

Give the connection between over-tones and vowel-sounds.

SMELL AND TASTE

Explain the intimate relation existing between taste and smell.

What part of the nose do we smell with?

With what two pairs of nerves is the nose supplied?

Through which pair is sneezing excited?

What connection exists between smell and the weight of the substance scented?

Where is the sense of taste located?

Give the five principal classes of tastes.

THE FOREST OF NERVES WITHIN US

In what way does a bundle of nerves resemble an ocean cable?

Will a nerve fiber carry messages in both directions?

How does the movement of a nerve-current compare with that of an electric current?

Of what is a nerve-fiber a part?

What office does the spinal cord perform in the economy of the body?

What is the function of the cerebellum?

MYSTERY OF THE BRAIN

What connects the two halves of the cerebrum?

Why is the surface of the brain folded in convolutions?

Is phrenology based upon sound principles?

Whence do we derive the power of association?

In what sense are our eyes at the back of our head?

HOW TO REMEMBER

When we say we have forgotten a thing, do we mean that there is no record of it in the brain?

Distinguish between memory and recollection.

What is the beginning of a memory?

Why is it easier to remember recent events than those which occurred long ago?

The converse holds with aged persons. Why?

HOW WE THINK

What mental process follows perception?

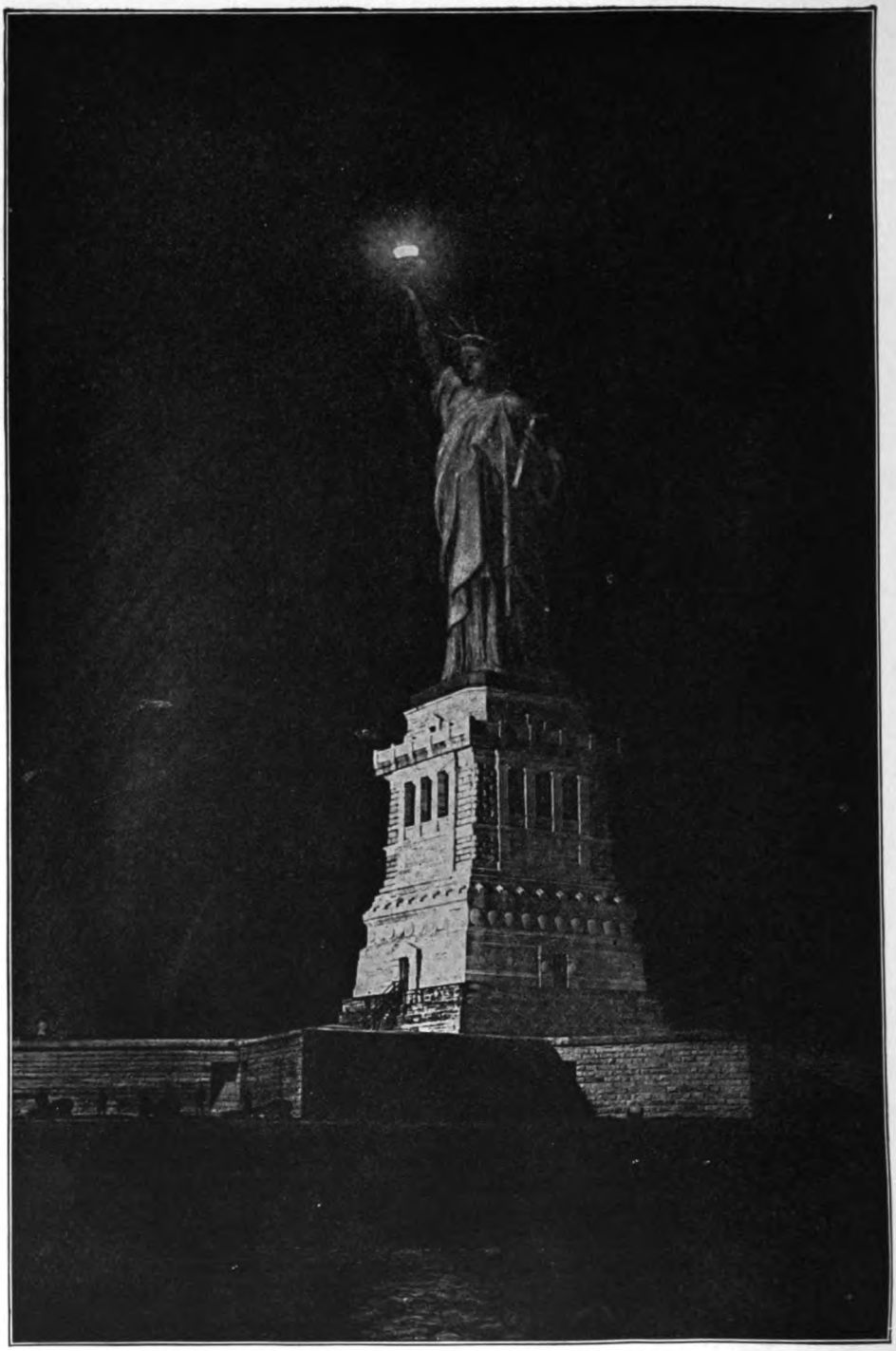
Give Bruno's great conception.

What is the motive power of thought?

What effect has perverted interest upon our thoughts?

Explain how the judgment may be led astray by feeling.

What is the distinction between a "walking encyclopedia" and a great thinker?



STATUTE OF LIBERTY ENLIGHTENING THE WORLD

Sculptured by Bartholdi and erected at the entrance of New York Harbor as emblematic of the civilizing influences of liberty upon modern civilization.

BOOK FOR PARENT AND TEACHER

THE MONTESSORI SYSTEM OF CHILD TRAINING

Underlying Ideas of the System
Purpose and Educational Value of the Montessori Devices
Necessity of the Montessori Spirit
How a Montessori School Is Conducted
Montessori Exercises and Games
Use of the Apparatus
Discipline and Obedience
Memory Tests on Montessori System

THE SCHOOL OF REAL LIFE

What a Boy Must Do to Succeed
What a Girl Must Do to Succeed

PRACTICAL ARITHMETIC AND PROBLEMS

The Fundamental Processes

Addition — Subtraction — Multiplication — Division — Fractions — Decimals — Denominate Numbers — Percentage — Interest — Taxes — Insurance

Problems and Calculations in Connection with:

Education and Industry — Fencing — Drainage — Plowing — Wheat — Corn — Potatoes — Birds and Insects — Hay — Orchards and Spraying — Poultry — The Dairy — Roads — Silos — Problems with the Lever — Animal Power

Handy Values, Weights and Measures

FARM SCIENCE AND PRACTICE

Choosing a Farm
Rotation of Crops
Preserving Foods
Plant Life
Fifty Farm Birds
Stock Feeding
Fertilizers
Concrete Construction

DR. MARIA MONTESSORI

The famous Italian physician and educator who founded the Montessori system of child education.

MONTESSORI SYSTEM OF CHILD TRAINING

FOR HOME OR SCHOOL

This Book explains how to train and develop the special senses; how to keep children properly occupied; how to train their bodies; how to use all necessary apparatus; and how to enforce discipline and obedience.

THE Montessori method is a new system of education for very small children devised by an Italian woman physician. One of the first facts rediscovered by Dr. Montessori is the old threadbare truism that every child is different from every other child. She found not only that but also that not being a fixed and inanimate object, he is in a constant state of flux, and differs from himself, from day to day, as he grows. His attention, his memory, his mental endurance, his intellectual interest and curiosity, are not only unlike those of the child next him in school, but will be tomorrow different from what they are today. It was evident to her that the usual "class recitation" and "class lessons" were out of the question, since they could at the best, possibly fit the needs of only one child in the class. And yet it is obviously impossible, as the world is made up, to have a teacher for every child. There was only one way out—things must somehow be so organized and arranged that, for most of the time, the child can and shall teach himself.

UNDERLYING IDEA OF THE SYSTEM

And here Dr. Montessori found herself in accord with another fundamental principle of the growth of childhood, which she had discovered or rediscovered and which may be said broadly to be the master idea of her system. The central idea of the Montessori system, on which every bit of apparatus, every detail of technic rests solidly, is a full recognition of the fact that no human being is educated by anyone else. He must do it himself or it is never done. The learner must do his own learning, and this granted, it follows naturally that the less he is interfered with by arbitrary restraint and vexatious, unnecessary rules, the more quickly, easily and spontaneously he will learn. Everyone who wishes to adopt her system, or to train children according to her method, must learn constantly to repeat to himself and to act upon, at every moment, this maxim, "All growth must come from a voluntary action of the child himself."

THE SYSTEM MUST FIT THE CHILD

In this respect again Dr. Montes-

sori took the stand that education must be made to fit the child, and the child not forced to fit a preconceived idea of what education ought to be or do. She laid down the principle that one of the essentials of education is that children shall get that individual attention they need so much, by giving it to themselves, each child being his own teacher. She now further stated as another essential element that education should be so organized that the child shall ardently desire to teach himself and shall enjoy doing it more than anything else.

BASIC PRINCIPLES OF MONTESSORI SYSTEM

To reduce, then, to the barest outline this new system of training children, one can say that it rests upon a full conviction of these three facts about the nature of children:

First.—Children are all different from each other, and hence need for their fullest development, the greatest possible liberty for their individualities to grow; and that, though of course there are many points in common, they must not be treated in the lump, but individually.

Second.—Children cannot, so to speak, learn from the outside. That is, that the impulse to learn must come from within their own minds. There are absolutely no exceptions to this rule. Children must wish to learn, or it is a physical impossibility for them to do so.

Third.—Children are so made that, given proper conditions, they prefer educating themselves to any other occupation.

A DAY WITH THE CHILDREN'S ACTIVITIES

What has been said thus far is almost certain to have aroused in the minds of many readers the question, "How in the world does Dr. Montessori accomplish all this?" or, perhaps the more skeptical exclamation, "It can't be done, by Dr. Montessori or anyone else!" How can children teach themselves? How can they learn without detailed verbal instructions from a teacher?

How does a boy learn to climb an apple tree? By being turned loose in company with the tree at that period of his life when he feels a surging natural impulse to climb trees. A boy of three can play about the foot of an apple tree day after day and no more think of climbing it than we of walking the ridge pole of our house. A man of twenty-one can play tennis, or plough, under the tree's branches with a similar lack of monkey-like desire to climb from branch to branch. But somewhere between those ages, there is a period in every normal life when, if the opportunity is present, a vast amount of muscular agility, strength and accuracy are acquired, together with considerable physical courage, some daring, some prudence, and a fair amount of good judgment, all without the slightest need either to force or persuade the child to the acquisition of these desirable qualities.

THE PURPOSE AND EDUCATIONAL VALUE OF THE MONTESSORI DEVICES

Now, for all intents and purposes, the Montessori apparatus, so much talked of, so scientifically and ingeniously devised, is simply composed of supplementary apple trees. It is made up of devices and inventions which are intended, first, to stimulate the little child's natural desire to act and learn through action; second, to provide him with action which shall give him a better control of his own body and will-power; and third, which shall lead him naturally from a simple action to a more difficult one.

TRAINS THE FIVE SENSES

In the case of very little children this is (as far as concerns the formal

SELF-EDUCATION BY THE MONTESSORI SYSTEM

At undirected play with the didactic or sense-training materials.

Montessori apparatus sold) largely connected with the training of the senses. The importance of this detailed, direct education of the five senses may not be at first apparent. But it is evident that our five senses are our only means of conveying information to our brains about the external world which surrounds us, and it is equally evident that to act wisely and surely in the world, the brain has need of the fullest and most accurate information possible. Hence the education of all the senses of a child to rapidity, agility and exactitude, is of great importance—not at all for the sake of the information acquired at the time by the child, but for the sake of the five, finely accurate instruments which this education puts under his control.

MONTESSORI SPIRIT IS THE FIRST ESSENTIAL

Much has been written and said about the Montessori Didactic Apparatus, but the use of her apparatus without an understanding of the underlying principles and without the spirit that animates all true Montessori work will result only in confusion and disorder. The Montessori Didactic Apparatus is a part of the system, but the most vital element is the Montessori spirit. The mother on a desert island who is dominated by Dr. Montessori's love and respect for the child would accomplish much more without the formal apparatus than a mother who uses it without the sympathy and understanding requisite for success.

THE CASA DEI BAMBINI

If you wish to see a typical Casa dei Bambini (which means Children's Home) you are to imagine thirty children turned loose in a big room, furnished with little chairs and tables, with room outdoors, close at hand, where the children may run and play when they feel like it, a quiet, gentle, alert, nearly always silent superintendent, to whom all those little self-teachers turn for advice in their educational career; a piano in one corner of the room, to the music of which once in a while those children who feel like it dance and play. There are soft rugs on the floor, on which those children who feel tired may lie down and rest whenever they like. On the walls there are pleasant pictures of subjects suitable for little children. There are window-boxes of plants, tended by the little pupils; there are in one corner some little wash-stands with small bowls and pitchers where the children wash their own faces and hands, whenever they are dirtied by their work or play. In fact, the room and its furnishings are exactly like what every mother would like to give her own children in her own home. The Casa dei Bambini is truly a "Children's Home"—a place for self-reliant work and contented play.

FEEL A RESPONSIBILITY

The children learn to feel, because they are allowed to, a real responsibility for the condition of this, their very own home. Before they begin the morning's work, they clean the schoolroom, using tiny brooms and dustpans, just the right size for their little hands, and they make their own morning toilets neatly and cheerfully at the little washstands. They all seem like brothers and sisters of one big family, living the happiest and sanest of family lives together in one big, well-furnished nursery. They form groups of two or three, over some difficult problem; or four or five in a game with some part of the apparatus which needs a number of children together; or ten or twelve in a ring-around-the-rosy game to the music of the piano. Out in the playground, bright with flowers and plants of their

own tending, there are always some children playing "blackman" or "blindman's buff." No one makes the slightest effort to induce them to stop playing in order to come and learn their letters or the simpler processes of arithmetic. They do so of their own accord. It has been found, first, that although they are free to do so if they wish, they no more wish to spend all their time in playing children's games than workers in a candy factory desire to consume chocolate drops all the time.

VALUE OF FREE-WILL OVER ENFORCED ATTENTION

The second discovery is of even greater importance than the first; is in fact of such vital importance that it cannot be too often stated. This is the discovery that one moment of *real* attention, given of the child's own free will, with actual vivifying interest back of it, is worth more educationally than hours of enforced listening to a teacher teach. Such a moment of real attention is worth more because it is worth everything, while the enforced listening to teaching is worth nothing.

LUNCHEON IN THE CASA DEI BAMBINI

—The children, as a rule, busy themselves happily with the different parts of the apparatus most of the morning. Towards noon, preparations for luncheon begin. The children take turns in doing this work, four or five being charged every day with the responsibility of setting the tables, bringing in the soup tureens, and serving their little mates. There is no better description of this most interesting and valuable part of the routine of the day than the passage in Dr. Montessori's own book, *The Montessori Method*, page 348: "Any one who has watched them setting the table must have passed from one surprise to another. Little four-year-old waiters take the knives and forks and spoons and distribute them to the different places; they carry trays holding as many as five water glasses, and finally they go from table to table, carrying tureens full of hot soup. Not a mistake is made, not a glass is broken, not a drop of soup is spilled. All during the meal, unobtrusive little waiters watch the table assiduously; not a child empties his soup-plate without being offered more; if he is ready for the next course, a waiter briskly carries off his soup-plate. Not a child is forced to ask for more soup, or to announce that he has finished.

EXERCISE THEIR OWN CHOICE

After lunch, the children again choose freely their own occupations. Some run out to play on the playground; some water the plants under their especial care; some take naps as long as they like. By far the greater number, however, return to the Montessori apparatus and occupy themselves with that fascinating material until time for them to go home.

MONTESSORI EXERCISES AND GAMES

TWENTY-NINE LESSONS WITH FULL DIRECTIONS TO MOTHER AND TEACHER

Including: How to fix the child's attention on size and form. How to co-ordinate movements of the fingers. How to distinguish differences in size and form. How to develop the sense of touch. How to train the sense of hearing. How to teach the child to write. How to teach the child the *abstract* from the *concrete*. How to teach the child the use of colors. How to train the child in bodily movements. How to teach the child the alphabet. How the child learns self-care. First steps in numbers. Arithmetical games. How to teach discipline and obedience. How to supplement Montessori apparatus.

WE IN America who have children between the ages of two and seven can not as yet send our children to one of the special schools. Therefore, if we wish our children to profit by the great work of Dr. Montessori, we must do the next best thing, and give them the Montessori training in our own homes. The fact that we have only the children of our own home to deal with should not lessen the sense of responsibility or the diligence with which we strive to make daily application of the Montessori principles.

A SCHOOL IN THE HOME

The mother has some advantages which the superintendent of the Montessori schoolroom does not have. She has the children constantly with her, and she can, if she will, turn into a Montessori exercise almost everything the child does in the course of his waking hours. These valuable and constantly present opportunities for supplementary Montessori work in ordinary home life will be touched upon as the regular apparatus is described and explained in the following lessons.

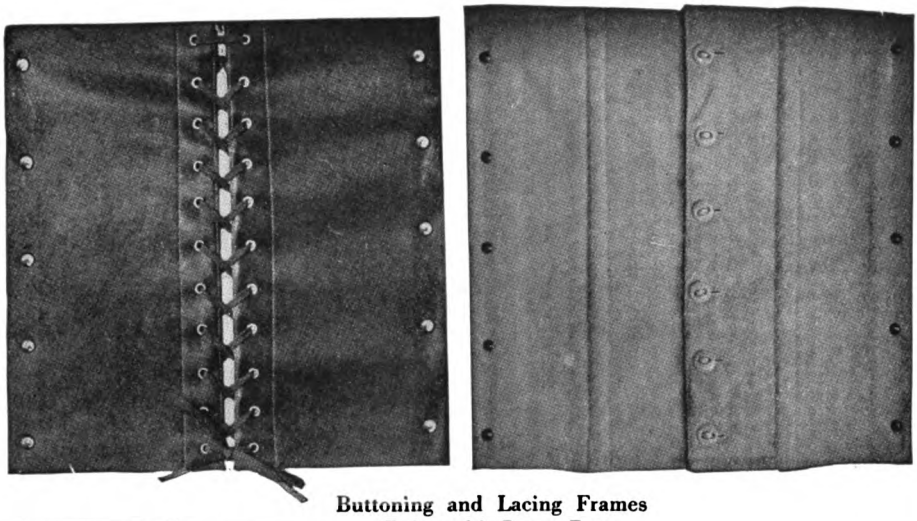
Let us suppose that the box containing the Montessori apparatus comes into the home when the three-year-old child for whom it is intended is asleep. The mother takes her time to look over the large collection of queer-looking objects and, if she is wise, puts away, for the present, everything but the simplest of the Buttoning Frames and the three sets of Solid Geometric Insets.

EXERCISE ONE

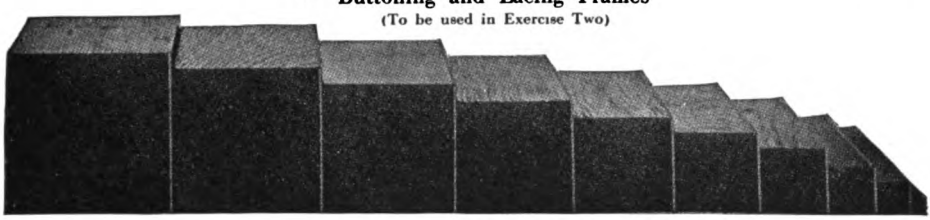
TO FIX THE CHILD'S ATTENTION ON SIZE AND FORM

Solid Geometrical Insets.—These comprise three series of wooden cylinders set in corresponding holes in a thick, smoothly planed board. There are ten cylinders to each of the three series. In the first, the height of the cylinders is constant and the diameter varies; in the second series, the diameter is constant and the height varies; in the third series, the cylindrical form alone is constant, height and diameter varying. With these insets, the child, working independently, learns to discriminate objects according to thickness, height and size, and the material used controls the error.

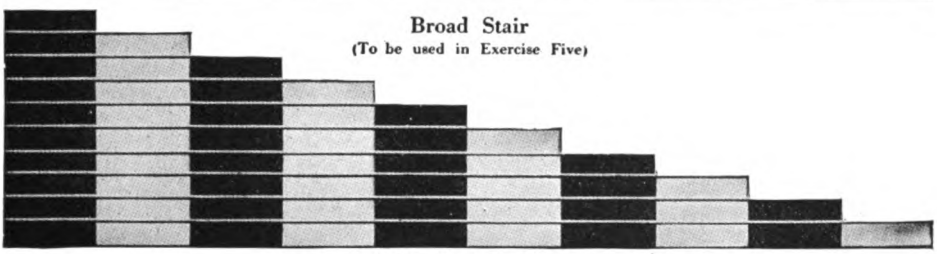
When the child wakes up, he is told there are some new playthings in the house, and one of the Solid Geometric Series is shown him. As a rule, he needs no further supervision in the use of this piece of apparatus, since it is self-corrective. If he gets a small cylinder in the big hole, when he comes to the small hole, the big cylinder will not go in it, and he is forced to look back to correct his own mistake. Here, as in the use of all the Montessori apparatus, it is well to remember that the best thing one can do for the child is to let him alone as much as



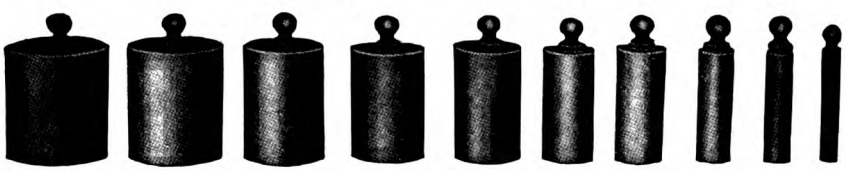
Buttoning and Lacing Frames
(To be used in Exercise Two)



Broad Stair
(To be used in Exercise Five)

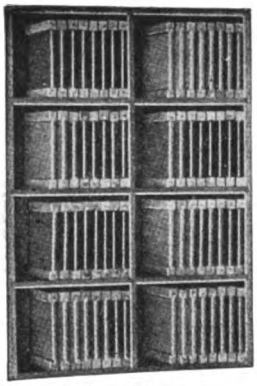


The Long Stair
(To be used in Exercise Six)



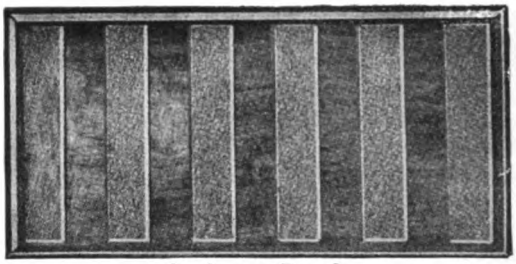
Solid Geometrical Insets
(To be used in Exercise One)

MONTESSORI SENSE-TRAINING APPARATUS



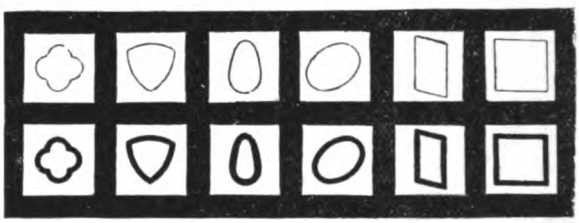
Color Boxes

(To be used in Exercises Sixteen and Seventeen)



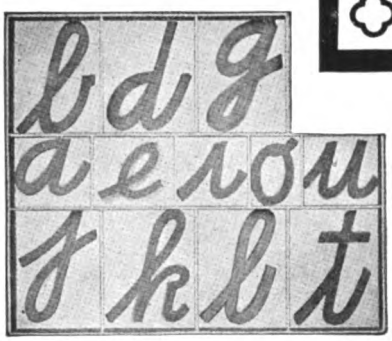
Sandpaper Boards

(To be used in Exercises Seven and Eight)



Plane Geometric Forms

(To be used in Exercise Thirteen)

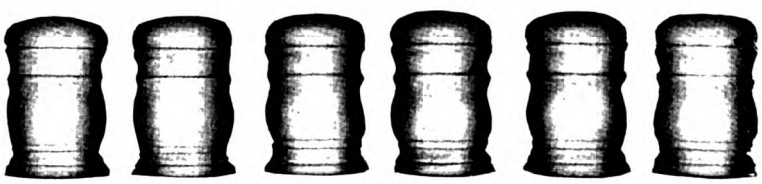


Part of Movable Alphabet

(To be used in Exercise Nineteen)

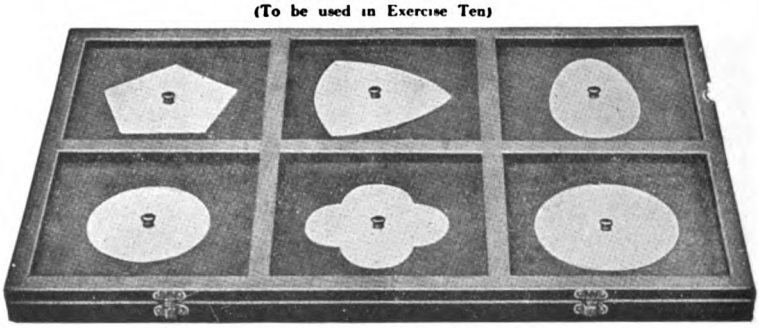
Computing Boxes

(To be used in Exercises Twenty-three and Twenty-four



Sound Boxes

(To be used in Exercise Ten)



Plane Geometric Insets

(To be used in Exercises Eleven and Twelve)

possible. "Hands off!" is the motto for adults in adopting the Montessori system for a child. The important thing is not that the cylinders shall all be put back in the right holes, but that the child shall do it himself!

Any ordinarily active, right-minded baby of three will fight for this right himself, pushing away help and crying "Let me," and the adults should religiously respect this desire to begin a life of self-independence. And yet, of course, adult brains can often devise some method of using the apparatus which will make the process of learning self-independence easier for the child. One of the discoveries made by Dr. Montessori is that the sense of touch is very much more developed in little children than the sense of sight; that is, they can tell more about an object after they have handled it than if they have merely looked at it. So that it is well to explain to a child who has difficulty in getting the cylinders back in the right hole that if he holds a cylinder by the little knob with the fingers of his left hand and passes the forefinger of his right hand around the base of it, and then around the opening into which he thinks it ought to fit, that he will probably be more accurate than if he merely looks at the two objects.

TRAITS OF CHILD NATURE APPEALED TO

It is well that the mother should understand just why the child should be interested in these exercises. There are two fundamental traits of childhood involved: first, any normal child takes a great interest in putting objects in rows; second, any child is delighted when he can put an object into an opening. Combining these two traits of childhood, we have a fascinating educational device. The child is not only happily employed but he is learning something that is of value. He is learning to discriminate between different objects. Although he does it unconsciously, he is forming an idea of spacial relations.

When the child can successfully put the various cylinders in their respective openings, the exercises can be made more complex by giving all the cylinders to the child and only one of the bases. This requires a greater discrimination, making the exercise more complex. The cylinders can also be used a little later in teaching nomenclature, to show the difference between thick and thin, thicker and thinner, high and low, higher and lower, etc.

After he has mastered the simpler exercises, the child may be blindfolded or, looking in another direction, place the various cylinders into the openings. These exercises bring into play the tactile and muscular senses, both of which are very acute in small children. Since the child delights to feel of objects, it will not be long until he will take a great interest in the game of "seeing with his fingers." These sets of cylinders are perhaps the simplest of all the equipment and at the same time they have proved the most fascinating for small children.

THE TRACING OF FORMS, "THE BEGINNINGS" OF WRITING

The child should be cautioned (and his mother should take pains about this in all Montessori exercises) to make the motions always from the left to the right, in the directions in which writing is done, for these exercises, unlikely as it seems, are the beginnings of writing and reading. Then he should be left to "play" with this new toy, as long as his interest lasts, which will vary greatly according to the degree of development reached, the temperament of the child, and even his state of health. When he is perfectly well and rested and not

hungry, he can do much better work than otherwise. His attention to the exercise must, of course, be spontaneous, brought about by the interest of the task given, and if the task does not happen to interest that particular child at that particular moment, nothing can be gained by forcing him or even coaxing him to go on with it. He will return to it another day, or perhaps even an hour later, of his own accord.

EXERCISE TWO

FOR CO-ORDINATING MOVEMENTS OF THE FINGERS

The Buttoning or Dressing Frames. —There are eight of the dressing or buttoning frames. Any one or more of these can be used effectively without association with the others. On six wooden frames are mounted six pieces of cloth of varying textures, to be joined by means of large buttons and buttonholes, automatic fasteners, small buttons and buttonholes, hooks and eyes, colored ribbons for bow-tying, and lacing through eyelets. The remaining two frames are mounted with leather pieces, one of which simulates shoe lacing and the other shoe buttoning, the latter involving the use of the button hook. These exercises are for the development of co-ordinate movements of the fingers. The child is taught to dress himself without his really knowing that a lesson is being taught him.

The Buttoning Frame, or the frame with "hooks and eyes," should be brought out first, and the method of fastening and unfastening explained in the usual Montessori way; that is, as briefly as possible. It is often best not to say anything, but merely to go through the exercises one's self, unbuttoning or unhooking the cloth, buttoning or hooking it up again, and handing the frame to the child. In most cases he at once sets to work, and even though his first efforts seem to the observing mother incredibly clumsy and slow, she must keep her hands off, and let him work out his own problems.

PUTTING AWAY THE APPARATUS

The only rule should be that if he does not wish to play with the apparatus, or when he grows tired of its use, he should put it away; and for that purpose it is very essential that there should be a well defined place, which the child can easily reach, for every one of his belongings—not only for the Montessori apparatus, but for his other toys and for his clothing. The hooks should be low, so that little arms can reach them, and the drawers where clothing is put away should be easy to open and shut. Three years is none too young to begin the habit of order, which, like so many other good habits, may be acquired painlessly at an early age, although so nearly impossible to inculcate after the bad habits have become fixed.

The exercises with the dressing frames are not necessarily for the developing of the different senses. The primary object is to develop the muscular coordination to strengthen the child's little fingers. These materials carry out Dr. Montessori's ideas of simplicity, self-correction and general attractiveness. They are so simple that the child at once understands the meaning of the game, and in working with these various materials his little fingers and hands are so strengthened that he may successfully take up more complex and difficult work.

Of course, one of the incidents of this work is that he learns to dress and undress himself, This, it should be remembered, is not the primary factor that Dr. Montessori has in mind,

EXERCISE THREE

SUPPLEMENTARY EXERCISES TEACHING THE PRACTICAL APPLICATION OF KNOWLEDGE GAINED WITH THE APPARATUS

One obvious result sought in all these exercises is the beginning in the child's mind of the habit of concentration to the task in hand. The insets are primarily intended, as already stated, to teach the child to distinguish between differences in dimension and form, and this can be taught by supplementary exercises in almost any room of the house.

First.—In the dining-room he can be given a pile of spoons of differing size, teaspoons, tablespoons, soup-spoons, coffeespoons, etc., and the suggestion made to him that it would be fun to separate them into piles according to their sizes. In most cases, this impromptu Montessori exercise can be depended upon to amuse the child for an astonishingly long period, and it is, of course, excellent training for his capacity to distinguish accurately between objects similar but of different size.

Second.—Out of doors, a pile of stones of differing sizes can be divided into several piles of the same size. Most mothers will be surprised at the vast and inextinguishable interest taken in such simple exercises by the average healthy child of three or over. The gain in accuracy of eye and brain is too obvious to need discussion.

Third.—The buttoning frames are intended first of all to teach the child to use his hands and fingers accurately and well, and next to enable him to dress himself as far as may be. This is very important, for the first thing to be done for a little child is to release him as quickly as possible from the prison of babyishness—to make it possible for him to take care of himself, and not to depend upon the services of others. As his clothes are nearly always fastened with buttons, it is essential that considerable time be devoted to teaching him how to manage these, or, rather, that he shall be allowed to take the time necessary to learn this. For he has a natural fund of desire to manage himself which makes him eager to learn.

The buttoning frames, being of cloth tightly stretched on wood, are easier for him to manage than the buttons on his own clothes, although as soon as he begins to try to button his own coats and waists, he should be allowed all the time he needs for his first clumsy and ineffectual attempts. Remember, he should be allowed all the time he needs—not all the help he needs! For if he is often helped, he will fall into the vicious, invalid's habit of waiting for other people to serve him.

Fourth.—The lace and ribbon frames are more difficult to use and are, of course, to be held back until the child is older, perhaps four or five. From time to time, they should be brought out and a simple experiment made of the child's capacity to deal with it. If he does not at once show interest in the problem of bow-knots and laces, and more of a capacity to struggle with the construction of them than on the last trial, the frame should be taken away, without comment, and not tried again until more progress has been made in the other exercises. It must be remembered, as a general rule for the use of the Montessori exercises, and in general in the training of little children, that no prolonged attempt should ever be made to coax them to continue an exercise which does not interest them. If they show no spontaneous interest, they are not ready for it, and time is only wasted by any attempt to force their inclination.

When they are ready, they can learn in ten minutes what three hours of dreary enforced practice was not able to teach them.

EXERCISE FOUR

EXERCISES FOUR, FIVE AND SIX ARE ALSO FOR THE FURTHER CULTIVATION OF THE CHILD'S VISUAL PERCEPTION OF DIFFERENCE IN DIMENSION AND FORM

The Block Tower.—After the child has had a day or so of practice with the Geometric Insets and Buttoning Frames, allowing him to take them up and lay them down at will, it is time to bring out the blocks composing the Tower. The Tower is a series of ten wooden cubes, decreasing in size. Almost every nursery possesses such blocks, but few mothers are aware of their educational value or of the distinctive use to which blocks of graduated size should be put. Their use should not be confused with that of the ordinary "building blocks,"—cube blocks of unvarying size. With the Tower blocks there are definite problems of classification and discrimination to be solved, and to get the benefit of them, the child must use them in the one correct way.

TEACHING THE CHILD TO BUILD THE TOWER

The mother builds up the Tower before the child's eyes, placing the largest block first, then the next smaller one, and so on down to the tiny little cube at the top. Then she knocks it all down, and if her child is the average child, he needs no more incentive to duplicate the performance and to begin to educate himself as to graduations of size. When he begins to construct the Tower himself, the difficult thing for the mother to do is to avoid giving him elaborate instructions: "No, no, Jimmy—not that one—that's not the next size—don't you see the one by your hand is bigger?" etc., etc., etc. The only good Jimmy can get of this exercise is by learning to see for himself which is the bigger block, and to do this his mother must let him alone. She need not be surprised if he makes one odd mistake continually, even after he has learned quite deftly to construct the Tower. A great many children find it difficult to begin the Tower with the biggest block. They begin it with the next biggest, and, when they have finished, find that they cannot place the largest one without tearing down the whole structure. The psychological processes involved in this mistake are too complicated to explain here. I mention it, lest some anxious mother should think her own three-year-old especially deficient in the capacity to distinguish between sizes.

One exercise that can be profitably carried out is to give the Tower to the child and have him carry it, let us say, from one part of the room to another. In all probability, his first attempt will be far from successful. Let him take his own time in the building of it, and then make another attempt. Finally, he will be able to carry it very successfully from one part of the room to another, thus showing the self-control that is developed.

EXERCISE FIVE

BROAD STAIR

After the Tower, the next exercise is the Broad Stair. It is a set of ten rectangular wooden blocks, decreasing in height and width, length only being constant. This is another of the visual perception exercises. Here it may be well to mention that when a new exercise is given a child, the older ones are by no means taken away. They are left in the nursery, where he can get at them himself whenever he wishes to, and the new ones simply added to the store

of his riches. Often, when the more elaborate exercises are quite mastered, a child will take pleasure in returning for a time to the simpler old friends with which he began. He should be allowed to do this quite as he wishes, his own instinct being a sure and accurate guide to what is best for him in this respect. He is doing what we all like to do occasionally—he is "reviewing" what he has learned, and making sure of his grasp on something which he has not thought of for some time.

The Broad Stair is brought out in the same quiet manner with which the child has been introduced to his other Montessori "playthings." The mother arranges the blocks in regular order, starting either with the biggest or the smallest, and laying the others side by side, until a regular stair is constructed. Then she mixes the blocks up, and goes away. The child, if he is ready for this exercise, at once takes it up, and in struggling to repeat his mother's feat, constructs the stair, intellectually as well as physically, and learns a new variety of dimension. Since all these blocks are the same length, and only differ in height and thickness, his problem is one degree more difficult than in the construction of the Tower.

It should be remembered about these blocks, as about all Montessori apparatus, that they should be used for the purpose for which they are intended and for no other. The child should always have, in addition, an ordinary set of plain building blocks, with which he can play in any way he pleases, and if he begins to "make houses," etc., with his Montessori blocks, his little mind, incapable of more than one idea at a time, should be redirected to the regular exercise involving the dimensions of these blocks.

EXERCISE SIX

THE LONG STAIR

After the Tower and the Stair comes the third set of blocks, or rods, called the Long Stair. This is the most important of the three sets, as it is the foundation for instruction in arithmetic. With this set of short rectangular rods, the child learns, as he grows older, a number of the simpler processes of numeration. At first they are presented to the child just as a series of rods differing in length, the smallest one being one tenth of the length of the longest one. The mother builds up the series, having the child notice that all the rods are red on one end, and that the stairs have a regular number of red and blue spaces from one to ten, or from the bottom to the top of the stairs. Then the series is knocked over, the rods mixed up, and the child left to put it together again himself. Children who cannot definitely count can often manage this series, and it is the greatest pleasure for the child who has just learned to count to be able to verify his numbers in this concrete way. For the present, this is all that is done with the Long Stair, but as the child progresses and develops, it will be found one of the most valuable parts of the apparatus, because the rods can be combined in many different ways, and illustrate in the plainest and most unmistakable manner many of the simpler processes of mathematics — addition, subtraction, etc. But this all comes later, and after the child has mastered other of the apparatus.

ORDER OF EXERCISES TO BE MODIFIED ACCORDING TO CIRCUMSTANCES

It is not desirable that we give directions for the exact use and the order of succession of the remainder of the apparatus. Children differ so widely that the mother will be forced

CHILDREN DIRECTING THEIR OWN LESSONS

A spontaneous writing lesson. These children have reached the point where, as Montessori says, they "explode into writing."

Montessori Long Stair Game.

to depend somewhat on her own judgment and intimate knowledge of the child. She will have grasped by this time the purpose of the exercises with the Montessori apparatus, which is *to give the child the fullest possible control over his own body and will-power.* The order of exercises as hereafter indicated is to be followed with any ordinary child, but this must be modified according to circumstances.

EXERCISE SEVEN

DEVELOPING THE SENSE OF TOUCH

Sandpaper Board Number One.—As a rule, the next piece of apparatus to be taken up is the Sandpaper Board, a small board, one-half of which is smooth and the other half covered with sandpaper. This fixes the child's attention on the difference between surfaces. Sometimes this is one of the very first apparatus to be used, as a distinction between rough and smooth is apt to be one which arouses the interest of a very little child. His mother takes the board in her lap, or lays it on the child's small table, and draws the little finger-tips over the smoothly planed board, saying at the same time, "smooth, smooth." Then she draws the finger-tips (always from left to right) over the rough sand-paper, saying, "rough, rough." The child very soon associates the sound with the sensation, to which his finger-tips are more alive than are deadened adult fingers, and says himself, as he touches the two surfaces, "smooth, smooth—rough, rough." After this distinction has been thoroughly learned (it may take only one lesson, or it may take two or three days), it is a good plan to try to see if he can make the distinction accurately when he is not looking at the board, purely by the sense of touch. The finger-tips should then be passed, always with the utmost delicacy and with the lightest possible touch, over the two surfaces, and the child asked to give the right name to what he is touching. At the first sign of mental fatigue or confusion, this exercise should be discontinued, although it may be taken up again after a half-hour's rest and change of occupation. The child's fingers should always be trained from left to right.

EXERCISE EIGHT

SANDPAPER BOARD NUMBER TWO

When the simpler of the sandpaper boards has been mastered, the child may go to the next form, in which the sandpaper is arranged in alternate strips on the smoothly planed board. This is, of course, more complicated, and the blindfolded child may soon "lose his head" and not be able to distinguish accurately between the sensations. He should be encouraged to take plenty of time, and to allow his finger-tips to play freely across the surface. When he can tell quickly accurately, and without mental fatigue, whether he is touching a rough or smooth strip, the beginning of the child's education of his tactile sense is well made. He has taken the first step, which counts so much, and will go on steadily to more complicated conquests. In this exercise, the child is also learning to follow a raised surface with his little fingers. This is of great value to him as a preliminary to the sandpaper letters. After he has mastered this simple exercise, he has one of the first requisites necessary for successful work with the sandpaper letters.

EXERCISE NINE

FOR THE FURTHER DEVELOPMENT OF THE CHILD'S TACTILE SENSE

In the formal Montessori apparatus, the small cabinet containing seven drawers is filled with various fabrics. These fabrics consist of two pieces

of the following materials: velvet, silk, wool, fine and coarse linen, and fine and coarse cotton. It is very important that absolutely pure fabrics should be used for these first exercises; in short, the mother should be quite sure that the linen she is using is not partly cotton. Of course, if the regular Montessori apparatus is used, all of these precautions are provided for. These can be supplemented by any ragbag, and from the infinitely diversified fabrics used in the furnishing of any home. When this "playing" with fabrics is first begun, the child is allowed to handle the different pieces of cloth, and his attention is called to the difference in their texture. He is told their names, one or two at a time, the mother taking the greatest pains to pronounce the words clearly, distinctly, and SLOWLY. When he has learned to distinguish them by looking at them, the next step, as with the sandpaper boards, is to distinguish them by the sense of touch only. The child can be blindfolded, or can look up at the ceiling, and, sitting in front of a mixed-up pile of the pieces, takes them up one at a time, pronouncing their names. When he has done this enough times so that he is quite sure of himself (usually after a week of playing with the pieces at intervals) he can go on to some of the fascinating "games" to be played with them.

SUPPLEMENTARY EXERCISES AND GAMES INVOLVING THE SENSE OF TOUCH

First.—The pieces are divided into two piles, each having the same number of pieces of the same fabrics. Then the mother picks out a piece of velvet, without naming it, asks the child if he can find a piece like it in his pile (of course, without looking). This is always productive of much excited fumbling in the pieces, and much delicate fingering of them by sensitive little finger-tips, and finally much triumph when the matching bit of velvet is discovered. It may be said in passing that it is usually well to begin with either velvet or silk, as those fabrics are so markedly different from others that the problem is easier for a beginner. If two children play this "game," the victor is the one who first finds the piece of velvet without looking at his pile.

Second.—The mother's ingenuity can devise many other variations on this game, and can see to it that the child goes on observing the fabrics used in different parts of the house, the materials of which his own dresses are made, the stuff used in upholstery, table linen, curtains, etc. He can also be told the names of the different materials used in building a house—wood, iron, tin, glass, stone, and brick; and the materials of cooking utensils—china, tin, copper, etc. There is an infinite variety of material in the humblest home which can be the most valuable educational apparatus for the well-trained child, even in quite early childhood. Once the child's interest in this problem is aroused, he will in most cases go on educating himself, and all the parent needs to do is to have the patience necessary to answer innumerable questions.

Third.—Games with Balls, Squares, Triangles, etc.—Another "game" for developing the sense of touch with materials other than fabrics is played in the Casa dei Bambini with solid wooden geometric forms of differing shapes—balls, squares, triangles, etc. The child is blindfolded, and pulls these things, one at a time, out of a bag, identifying them solely by fingering them over. In the home this can be "played" with any material at hand with which the child is familiar. He can be blindfolded and try to identify objects in a miscellaneous heap on the table before him, consist-

ing of toy animals, spoons, forks, brushes, combs, dolls, trays—anything in the room which will not hurt him, and is not breakable. Very little children always experience the greatest joy in thus proving that they can see "with their fingers."

EXERCISE TEN

TRAINING THE SENSE OF HEARING

Sound Boxes.—But the sense of touch is not the only one of the child's five senses which can be improved by direct training. The sense of hearing is greatly developed and made more serviceable for after years, if given reasonable practice. The Montessori apparatus provides the wooden Sound Boxes, filled with different substances —sand, gravel, flaxseed, stones, etc., which give out sounds differing in quality and loudness, when shaken. The child's attention can be thus fixed, for the first time, on a definite attempt to distinguish between loud and low noises, as he shakes these little boxes close to his ear, and attempts to arrange them in order according to their degree of noise.

In all probability, the child has heard noises of this character, but he has not had an opportunity to compare or to contrast such noises. This exercise affords an opportunity for such discrimination. As a rule, the children take a great deal of interest in this simple exercise and they show a marked difference in their ability to discriminate between the various substances.

SUPPLEMENTARY EXERCISES AND "GAMES"

But this simple exercise needs to be supplemented by other "games" which fix the attention on sounds. These can be devised most easily with "hide-and-seek" games. The mother hides and blows very softly a little horn, by means of which the child traces her; or she calls the child's name in the lowest possible whispers, as he, blindfolded, tries to locate her in the room by his hearing. Any of the common children's games, "blindman's buff," "still-pond-no-more-moving," etc., played with a blindfold, are excellent exercises for the same purpose.

Out of doors, long-distance calling may be used for this purpose, to accustom the child to determine the direction from which any noise comes.

As to musical sounds, most children who are young enough for this Montessori training are too young to distinguish pitch at all accurately. Of music they receive practically nothing but rhythm, although they are fond of marching to a tune which has strongly marked time, and this is a good exercise for them, in its place.

EXERCISE ELEVEN

PREPARATORY EXERCISE FOR TEACHING THE CHILD TO WRITE

Plain Geometric Insets.—Very soon after the child's first introduction to the Montessori apparatus, he can begin his use of the Plain Geometric Insets. These sets consist of a six-drawer cabinet, thirty-six geometrical insets, and a pattern in an adjustable frame, making possible any desired combination of forms. The insets are made of pieces of smooth wood, painted blue, cut in different shapes, and with a little knob-like handle in the center. These insets fit into holes or openings cut in a rectangular natural colored piece of wood. The first of the series of six drawers contains insets of strongly contrasted forms; the second drawer contains a series of six Polygons; the third drawer, a series of six Circles, diminishing in size; the fourth drawer, a series of Quadrilaterals containing one square and five rectangles; the fifth drawer, a series of

six Triangles, and the sixth drawer contains Oval, Ellipse, Flower Forms, etc. These have such a vital part to play in the training of the child to write, that the mother should be especially careful in the way they are used.

The entire thirty-six different shapes should not, of course, be put before the child at the beginning but only a drawer of the most strongly contrasted shapes—triangles, oblongs, etc. He should be taught at the very start (as in the case of the solid geometric insets) to aid his sight by touch. While he holds the inset by the little knob with his left hand, he traces the outline of the inset with his right forefinger, and from left to right, or in the direction in which writing is done. Then, while still holding the inset, he traces around the outline of the depression into which he thinks the inset he holds would fit. It is quite important to establish this habit of tracing the outline with his fingers, as it has a vital bearing on learning to write.

As the child masters the tray of the more simple forms so that he finds it easy for him to place the insets in the corresponding opening, the less simple forms should be given him, a few at a time. After learning to distinguish between a triangle and a circle quickly and accurately, the next day he should be given two triangles and two circles of different sizes, to sharpen his sense of shape and dimension. After a time, he should be able to replace in the correct openings six triangles of differing shapes, and six circles of differing sizes.

It is perhaps well to give here the warning which can never be too often sounded—not to force the child's attention to this, any more than to any other problem. When mental fatigue sets in, and at the least sign of inattention, the tray of insets should be put away and some romping game outdoors played, or a quiet story told.

EXERCISE TWELVE

REPLACING THE INSETS BLINDFOLDED

When the insets have become old friends, it is well to try blindfolding the child, and setting him the new problem of replacing the geometric forms by the sense of touch only. Here it is well to go back again to first principles and to begin once more with the easiest forms, until he grows accustomed to depending on his touch only. This is splendid practice, and a child who has had it grows astonishingly keen in his capacity to take in accurate impressions from his fingertips. How valuable the ability to work without looking at what is being done, can be estimated from the experience of almost any variety of hand-worker. The old grandmother who knits without once looking at her needle can work all day long without a particle of fatigue, while the knitter who needs to be verifying each stitch by her eyes soon tires them out and must either stop working or suffer a violent headache. The stenographer who writes by touch has a tremendous advantage over the other who needs to use her eyes.

Dr. Montessori lays great stress upon the value of the work with these wooden geometric insets. They are so practical and at the same time so fascinating that the child learns a great deal in working with them. The primary object is that the child should learn form; that is, that he should see the difference between various objects. Ordinarily, this is a very tedious task for the child, but Dr. Montessori, by means of her self-correcting apparatus, has made a game that appeals to normal children. The mother should not be at all surprised if after a few

weeks of play with this apparatus the child should begin to point out various objects in his environment, comparing them with certain insets he has learned to know.

EXERCISE THIRTEEN

WITH WHICH THE CHILD'S COMPREHENSION PASSES FROM SOLID OBJECTS TO THE PLANE LINE, FROM THE CONCRETE TO THE ABSTRACT

Plane Geometric Figures Reproduced in Three Series of Cards.—After the final mastery of the geometric insets, the child is given a series of cards, representing the same forms as those of his insets. In the first of these three series, the forms are cut out of solid blue paper and mounted on white cards; in the second, the forms are cut out of heavy line drawings and mounted on the cards, and in the third, the outline or form is represented only by a thin blue line, such as is drawn by any pencil.

The child mixes up, say six or eight of these cards, and six or eight corresponding insets, and then sets himself the task of putting the insets on the corresponding card. Here he has not the sense of touch to guide him, and learns gradually the meaning of the line, passing from the solid blue form to the form merely drawn in outline.

After the child has played with these various cards for some time he will have acquired a very definite idea of symbolism. That is, it will be comparatively easy for him to understand how a series of lines can stand for an object. Ordinarily, it is not difficult for the child to see the connection between a photograph and an object, but with an abstract line it is entirely different. What is there in the symbols c-a-t that would connect them with a cat? Dr. Montessori believes that the child should understand symbolism before the alphabet is taken up.

EXERCISE FOURTEEN

INVOLVING THE FIRST USE OF THE PENCIL

Plane Geometrical Insets Made in Metal.—And with this recognition of the line, might go very well with the average child the beginning of the use of the pencil. This exercise is done with the Plane Geometric Insets made of metal. Accompanying the metal insets in the formal Montessori apparatus are two wooden trays with sloping tops, large enough to hold three of the metal insets and intended to be placed by the child on his own table. It is, of course, unnecessary to point out that a small table and chair, just the right size for a child, are essentials in Montessori or any other right training for childhood.

The child puts a piece of white paper on the wooden tray or on his own table, then places the square inset over the paper and lifts out the central piece by its little knob. The white paper shows through the hole in the shape of the inset. The child is given a pencil and is shown, once, very briefly and simply, how to hold it and how to trace around the outline of the inset. He is apt to make bad work of this at first, as this is the very first use of the pencil, but his interest almost certainly carries him through the first difficulties. To begin with he simply traces the outline, lifts off the metal inset and admires the design on the paper beneath. The metal edge of the inset is a guide to his staggering little pencil and before long he will be able to make a good, clear outline, joining the ends neatly.

EXERCISE FIFTEEN

THE USE OF COLORED CRAYONS

First Lesson in Drawing.—When this has been accomplished the child is furnished with a box of colored crayons, and invited to fill in the "picture" he has made with strokes

of his crayon. The fact that he is working in color stimulates his interest and few children need more spur to advance than the simple permission to use the crayons. At first, and for many days, his efforts to fill in the outlines will be ludicrous in their inaccuracy. He should not be corrected, and should be allowed to pass from one form to another as often as he pleases, being supplied with an unlimited amount of paper and leisure for this new undertaking. Little by little, as he works at this accomplishment, along with other Montessori "games" he begins to "get the hang of it," in our vernacular phrase. The lines become more and more parallel, fewer and fewer go wildly outside the line enclosing the outline, and finally the geometric form is shown in color on the white paper almost as though it had been printed. This advance is not rapid, however, in the case of most children, and nothing should be done to hurry it. Occasionally a child gets tired of the whole process and will play with other things for several days without recurring to his "drawing," although on the other hand, some children are, from the first so fascinated by the problem that they can hardly let it alone. The child should be allowed to choose his own time for working at this and to spend as much or as little time over it as he wishes, although if there seems any likelihood that he has really forgotten it, his attention may be called to it again.

EXERCISE SIXTEEN

TRAINING THE EYE; THE MATCHING OF COLORS

Color Boxes and Color "Games."—At about the same stage of development that the geometric insets are first given to a child, the color boxes can be shown him and the color "games" begun. The color boxes are sets of spools, wound with silk of varying shades, eight of the main colors, and eight shades of each. At first the child is shown only two strongly contrasting colors, red and blue, for instance. The name is pronounced clearly and distinctly, holding up the corresponding color. When the child has grasped this the colors are allowed to lie on the table and the mother says, "Give me red," or "Give me blue."

When the child has progressed this far (this may be the next day, or even two or three days after the first introduction) the teacher or mother holds up a spool and asks, "What is this?" When the child can answer correctly, "blue" or "red," he has thoroughly learned those two colors and can progress to another one. When the eight main colors have been learned in this way, the child can begin to match them. Four spools are laid on the table, two red and two blue (of course of exactly the same shade). The child picks out the two red ones and lays them side by side, and then does the same for the blue. From this he can go by degrees until there are sixteen spools on the table, eight pairs, which he must put together.

EXERCISE SEVENTEEN

DIFFERENTIATION OF COLORS

After the matching has been mastered, the next step is to differentiate between light and dark shades of the same color, dark red and light pink, for instance, or dark and light blue. This goes in pairs at first also, but little by little, as the child's accuracy increases, he may go up to the eight shades of the different colors. Some Montessori children become so proficient that they can "carry a color in the eye," as it is called. That is, they can look at a spool of a certain shade of purple, go

across the room to a pile of spools and pick out the color matching it.

GAMES AND PRACTICAL APPLICATION IN MATCHING COLORS

With these color spools, a variety of "games" can be played, which any mother can invent, according to the number and age of the children wishing to play. They are all variations on the principle which is used in the game of "authors," and can be made simple or hard as circumstances direct. Furthermore, as in the treatment of fabrics, the child's attention is awakened to the presence of color in everything about him, and his interest aroused in the problem of determining the color of the carpets, curtains, dresses, etc., which he sees in his every-day life.

The reason for using these little spools upon which the silk is wound is that the child's attention is primarily directed to the color and not to the object.

The spools in themselves are very unattractive while the richly colored silk is just the opposite. Silk thread is used because it gives a deeper, richer color, at the same time is more practical and makes possible the various gradations.

Too much importance cannot be placed upon the developing of the chromatic sense in early childhood. If the child at an early age acquires a deep interest in shades and tints of colorings, he will not only be able to appreciate his environment much more, but this knowledge and appreciation of color will be of inestimable value to him in later years.

The ethical element in such training is also very important. If the child is taught to see the beautiful and to appreciate it even in his early years it must have a marked effect upon his later life.

EXERCISE EIGHTEEN

SPECIAL PHYSICAL AND GYMNASTIC EXERCISES FOR THE YOUNG CHILD

In connection with all these exercises with the Montessori apparatus there are a number of other exercises, chiefly gymnastic, which should be constantly in use. As soon as the child can walk at all, every effort should be made to teach him further and more definitely the art of equilibrium of his body. When we walk we continually balance our weight so that we do not fall down, and more accurately and unconsciously we do this, the better we walk. Now, bodily poise is one of the very important factors in bodily grace and even in strength, certainly in comfort.

THE CHALK LINE EXERCISE

In the Casa dei Bambini the exercise used for this need is arranged very simply by means of a long chalk line drawn on the floor. The children are invited to see how accurately they can walk along this line without stepping off. At first the little tots cannot manage this at all. Later they learn to walk very slowly along the line, and later, when they are four or five, to run as swiftly as deer along this line without swerving once from it.

WALKING THE TWO-BY-FOUR

A modification of this exercise can be arranged out-of-doors by laying a long piece of wood known as a "two-by-four" down on the ground and permitting the child to try to walk along it without falling off. He is usually ready to spend a long time at this exercise, and to return to it repeatedly. The benefit derived from this is beyond calculation.

ROPE-BALANCING AND WALKING BACKWARD

If a length of rope can be hung up where the child can reach the dangling end of it he will devise for himself a variety of exercises in bal-

ancing which will greatly increase his mastery of his body. Another exercise of great value for little children, is in walking backward. At first they need to be helped, for their little brains are so unused to reversing the processes of ordinary walking that they are quite helpless, but after a comparatively short time, they learn this new trick and practice it with delight. If possible every small child should have a little swing, just the right height for him, and a tiny spring-board ending over a pile of hay or anything soft, from which he may jump and learn to balance his body in the air.

THE BABY BALL

Most children of three are too young to have the least capacity for throwing or catching a ball, but if a ball is hung on a long string and tossed to them, the string retards the motion just enough to make it possible for their little brains to set their muscles in action, and they will play with great joy and profit for a long time, at this variety of "baby-ball."

ENCOURAGE CHILD'S INVENTIVENESS

Of course the greatest freedom should be allowed for any exercise (not injurious to the child) which his invention hits upon. The action so common among little children of throwing themselves on a chair or stool and kicking their swinging feet in the air is an excellent exercise for the muscles of the legs and should never be discouraged. To climb up and down a short length of ladder, with the rounds set at a distance appropriate for short legs, is also very beneficial.

SHOULD SHARE HOUSEHOLD WORK

A child who is being trained in the Montessori system should also, as soon as it is at all possible, begin to share in the work of the household. If he is provided with a small broom and dustpan, there is no reason why he should not keep his room fresh and clean, and also clean up any litter of paper or dirt which he makes in the course of the day. Setting the table is a singularly good exercise for a little child although of course it is enough to begin with, if he does only a small part of the whole operation.

The important element should be that what he does, he does entirely himself. If he is set to put a spoon at each place, he should be left (after due explanation as brief as possible) to wrestle with the problem and to solve it with his own unaided invention. Later he can be given all the silver to put in place, and as he learns in his Montessori exercises, *mastery over his muscles*, can be entrusted with china and glass at four and five years of age, which an untrained child of ten or eleven would be almost sure to break.

SUMMARY OF CHILD'S ATTAINMENTS IN THE MASTERY OF HIMSELF AND HIS WORLD

But to return to those formal and ingeniously devised "play-things" which so wonderfully and insensibly lead the little child to a mastery of his world and himself, let us suppose that the child for whom the box of apparatus came into the home, has now been "playing" with the different pieces of apparatus described for about three or four months, longer if he was only three when he began, a shorter time if he was older. He has learned to replace the geometric insets blindfolded by the sense of touch only, to distinguish fabrics and materials, to build the Tower, the Broad Stair and the Long Stair, to match colors, to distinguish between noises of varying intensity, to balance himself deftly, to manage a glass of water. His mother may very well consider that it is now time to begin to teach him the beginning of reading and writing.

EXERCISE NINETEEN

LEARNING TO WRITE AT THE AGE OF FOUR

Sandpaper Letters.—The child is told that there is a new game to play and the little box containing the famous sandpaper letters brought out. This alphabet is composed of letters in plain, round script, cut out of black sand, or emery, paper and pasted upon smooth white cards. Here at once the child's past practice in learning about objects through touching them, as well as looking at them, comes into play. He is shown a letter, the mother pronounces the sound of it clearly, and shows him how to trace around it with his finger in the way one would write it. He should touch it very lightly, as he has been taught to do with all his work, and should, at first, only trace the letters when some one is watching him, to make sure he does not do it backward, or upsidedown. Make sure that he knows the vocal sound of the letter or figure he is tracing. Most children of three-and-a-half or four have seen so much of writing among the adults of their acquaintance that their curiosity is deeply aroused as to the mysterious process and they are delighted with the prospect of learning something about it. They need, as a rule, no further incentive than the statement that this is the beginning of their learning how to write.

TESTING THE CHILD'S COMPREHENSION

As soon as a few letters are learned, the teacher, or mother, should make sure of the child's grasp of them in the same way she tested his knowledge of colors. She lays down four or five on the table and asks for a certain one. "Give me 'a,' please," or "Give me 'b.'" When the child can do this quickly and surely she next holds one up and asks him what it is. When he can identify those first letters he can be allowed to pass on to others; it will not be long before he has mastered all the letters.

RECOGNIZING AND SPELLING WORDS

Before that time, however, if his interest in the process is lively, he can begin to recognize words, and to compose them. If he has learned "p" and "a" he can compose the familiar word "papa," and will, in most cases do this of his own accord if his attention is called to the pronunciation of the word. If his mother says "How would you make this word?" and then pronounces it very slowly, separating the sounds distinctly, the child will analyze the word into its component parts. "It begins with 'p,'" she says, giving the phonetic sound and not the name of the letter. Of course the child reaches instinctively for the "p," and thereafter recognizes the sound of "a," puts the two together and looks on delighted at the first word of his composition.

EXERCISE TWENTY

LEARNING TO READ THE REGULAR MOVABLE ALPHABET

At this point the child should be presented with the Regular Movable Alphabet of cut-out script letters in stiff paper.

These come in two large, flat, pasteboard boxes with partitions dividing the same into separate compartments for each letter. There are four or five duplicates of each letter, making a like number of complete alphabets and, of course, additional letters can easily be made at home, if more are needed. These letters are not pasted on cards, like the sandpaper letters, and are easily handled and arranged as the child wishes, and with these begin his composition and recognition of words. He is not troubled, as in the old system, by the difficulty of forming

the letters, as all he has had to do is to take them from the compartments and make words with them, long before his little fingers have acquired the ability to handle a pencil surely and accurately.

PRACTICE WORDS

Of course English-speaking children have a much harder time to compose words from letters than Italian children, whose language is phonetically written. The English-speaking mother who attempts to teach her own child how to write and read, will infallibly become a convert to the simplified spelling idea, but, since it is out of the question for the present to change the wild insanities of English spelling, we must possess our souls in patience and exercise as much ingenuity as possible in introducing the little one to the life-long burden of an illogically spelled language. It is well for this purpose to choose for the first words, the very simplest ones, like "rat," "pin," "hen," "mama," "papa," "dog," etc., words which are not only within a child's natural comprehension but which offer no difficulties in the way of consistent spelling. When the inevitable difficulties occur, the best that can be done is to rely on the naturally quick memory of childhood, and to fall back on the helpless statement that "it's spelled that way because that is the way it's spelled." However, there is, even in English, quite a vocabulary of sensibly spelled words, which the child can acquire as a working beginning.

EXERCISE TWENTY-ONE

REVIEW EXERCISES WITH APPARATUS ALREADY MASTERED

Although he may from now on, "play" with the movable alphabet, the use of the sandpaper letters should be steadily continued, causing him to trace them *as they are written*, several times a day, if his interest allows. It is almost certain that he will ask to do this, as touching the letters brings home their form to his little brain much more certainly than merely looking at them. Sometimes children fail to recognize a letter when they look at it, although they can identify it perfectly after their fingers have traced it. This, being one of the essential steps in writing, must not be neglected.

At the same time that these exercises are being repeated as often as the child's interest makes possible, the exercises with "drawing," that is, tracing the outline of one of the geometric insets on the paper and filling it in with colored chalk, should also be steadily continued, for this *tracing teaches the child to use the pencil.*

THE EXPLOSION INTO WRITING

We quote from *A Montessori Mother* a paragraph describing the final success of these three exercises, "All these processes go on, day after day, side by side, all invisibly converging towards one end. The practice with the crayons, the recognition of the sandpaper letters by eye and touch, the revelation as to the formation of words with the movable alphabet, are so many roads leading to the painless acquisition of the art of writing. They draw nearer and nearer together, and then one day, quite suddenly, the famous 'Montessori explosion into writing' occurs. The teacher of experience can tell when this explosion is imminent. First, the parallel lines which the child makes to fill and color the geometric figures become singularly even and regular; second, acquaintance with the alphabet becomes so thorough that he recognizes the letters by sense of touch only; and, third, he increases in facility for composing words with the movable alphabet. The burst into

spontaneous writing usually only comes after these three conditions are present. It is to be noted that for a long time after this explosion into writing, the children continue incessantly to go through the three preparatory steps, tracing with their fingers the sandpaper letters, filling in the geometric forms and composing with the movable alphabet."

CAUTIONS TO BE OBSERVED

There are several cautions to be expressed about this whole process of teaching a child to write and read by the Montessori method. The most important one is against hurry. Even more consistently and steadily than with the rest of the apparatus, the child's natural gait ought not to be in the slightest degree hastened by urging from outside. He will go, in any case, so very much more rapidly, easily and surely, than children in school, that urging him is not necessary. The temptation with a bright quickly adaptable child is to attempt to "make a record." The mother should always act deliberately, she should take the greatest pains to be sure that the child understands every step before he passes on to the next and that he has thoroughly mastered one process before he is allowed to progress to another more complicated. Above all, she should refrain from forcing the child's attention in the slightest degree.

EXERCISE TWENTY-TWO

UNDIRECTED WORK; MAINTAINING THE CHILD'S NORMAL OR EVERYDAY LIFE

All the time that this work with the drawing and filling in of geometric forms, the tracing of the sandpaper letters and the composition of words with the movable alphabet is going on, the child's usual normal life should be continued. There should be plenty of *undirected* outdoor play, where the child's natural inventiveness has scope, "hide-and-seek" games, "tag," etc., with plenty of fun in the company of other children should be encouraged. There should be much reading to him of well-selected stories and poems suited to his age; with long hours of sleep, and a certain amount of helpful service about the household work. A "Montessori child" does not by any means signify a child who devotes most of his time to exercises with the formal apparatus.

PLANT AND ANIMAL PETS

He should have, if it is possible to arrange this, a plant or two of his own (even at the age of three) and a pet of his own, preferably a good-natured kitten, for he is rather young as yet for a puppy. He should assume the real responsibility for these plant and animal pets, caring for them himself. Later, he should have a little plot of ground, and learn from actual experience the wonder of growth from seeds.

HOW THE CHILD LEARNS SELF-CARE

He should have in his own room, or in a corner of another's (if he has no room of his own) a tiny washstand, with a little bowl and pitcher, light enough for him to handle, and a mirror hung low enough for him to see if he has succeeded in getting his face clean. He should be allowed the time necessary to wash his face and hands, and should be taught to empty the bowl and to keep his washstand neat and clean.

As soon as possible, he should be encouraged and allowed to dress himself, his clothes being made with this in view, although there must always be some buttons which three and four-year-old fingers cannot reach, and should assume the responsibility of putting away his own clothes and knowing where they are. People who have struggled with older children on these subjects will be surprised

to note how naturally and easily a little child will assume these helpful and desirable habits. The important point is to "catch him young," before he has learned bad habits of irresponsibility and sloth. Of course, there should be, as far as possible, the greatest amount of regularity and routine in the little life. He should eat his meals at regular hours, feeding himself and sitting at a low table; and he should take his naps regularly.

And this simple, industrious, tranquil life, with no excitements of joining in adult "pleasures"; full of profitable "play" which is educational, and permeated with a sense of responsibility on the child's part for the conduct of his own life, *is the Montessori life* for a child between two and seven. It is not enough that he construct the Tower, and the Long Stair, and learn his sandpaper letters perfectly; he must learn to be a self-dependent, self-respecting, self-trusting citizen of his little world.

EXERCISE TWENTY-THREE

FIRST STEPS IN ARITHMETIC

Counting Boxes and Sandpaper Numbers.—We have now to consider the question of arithmetic and the Montessori application of the subject to the child of the average American home. There is a prejudice about presenting mathematics to children under six, no matter how simply it may be arranged. But experience in the Casa dei Bambini has shown that children over three take a lively interest in the sequence of numbers, and in some of the simpler processes of arithmetic, if those processes can be presented to them in a sufficiently concrete form. The Montessori apparatus for this purpose is very simple, and can be supplemented by several other devices, easily obtained in any home.

These counting boxes comprise two small boxes, with five compartments or divisions in each. Accompanying the two boxes are fifty smooth, round sticks, exactly alike, and a set of numbers from 0 to 9, cut out of sandpaper and pasted on white cards. The counting sticks give the child a concrete basis for the abstract names of the numbers, and he learns to associate the symbol with the concrete object. At first the child does not play with the sandpaper numbers. These are removed from the boxes and he but wrestles with the problem of oral counting, using the sticks. One good way to begin is by arranging one of the boxes so there are no sticks in the first compartment, one in the next, two in the next, three in the next, and four in the last. This exercise is, of course, for a very little child who has no idea of the definite sequence of numbers, or of how to determine how many objects he holds in his hand. The other box is then emptied of all its contents and given the child, with an ample supply of the counting sticks, and he is invited to make his box exactly like the one his mother has arranged. Most children can, even at a very early age, quickly put one stick in the second compartment and two in the next. Here frequently, at the very beginning, there ensues some mental confusion, and much eager gazing at the three sticks in the box arranged by the mother. Anxious attempts are made by the child to lay an equal number in the next compartment of his own box.

The mother should not help in this process. It does the child no good if she interferes and does it herself, or corrects his mistake. If he has arrived at the age when his brain can master this simple arithmetical idea, he will ultimately solve the problem and place the proper number of sticks

in each compartment. If he has not yet arrived at the right age or state of development, he will not readily take in the significance of anything his mother may do, seeking to aid him. If he repeatedly performs this exercise incorrectly, or shows signs of mental fatigue, the boxes should be removed, and the attempt postponed until a later day.

The mental growth of children at this age is so astonishingly rapid that sometimes a child will be able easily to solve a problem only a week after he has found it perfectly impenetrable. It is far better to trust this principle of growth than to attempt to urge the child to put forth powers which he does not as yet possess.

BEGINNING TO COUNT

As soon as he can complete the series up to four, he can go on, one at a time, to complete the series up to nine, as shown in the illustration; and then, if he is the normal child, with a wide-awake, intelligent, curious mind, he will be observed "counting" everything in sight. He is delighted with his new acquisition, and employs it on all the material at hand.

EXERCISE TWENTY-FOUR

THE SANDPAPER NUMBERS ARE ADDED

Now is the time to bring out the sandpaper numbers. He is taught these just as he learned his letters, one at a time, and following the three regular steps. First, the mother guides the little forefinger over the rough sandpaper as the number would be written, at the same time pronouncing the name of the number, slowly and distinctly, and adding no explanations. She should refrain from wordy comments simply saying, "8," and show the little fingers how to trace the outline. Then she should lay several down on the table, and ask the child, "Give me '7,' or "Give me '2,' please." When he has mastered this she should then hold up a card and ask the child to tell her what it is. When he can do this accurately, he has mastered his numbers.

According to his age and capacity, this may take him two days, or two weeks. The next thing to do is to teach him to connect them with the right number of objects. And here the counting boxes come again into play. He should arrange the series, and place the right number in each compartment. The mother will be surprised to see that even after mastering the names and looks of the number and the sequence in the number boxes, the average child finds it quite an intellectual effort to put the two things together in his mind. He will need plenty of time and quiet to struggle with the new problem, and if it is too hard on the first trial, the number boxes should be taken away without comment, and some other "game" suggested.

EXERCISE TWENTY-FIVE

AN ARITHMETICAL GAME WITH THE LONG STAIR

Another arithmetical game is played with the Long Stair. The stair is arranged in sequence and a cardboard number corresponding with the number of rods in the section is leaned up against the section; "1" against the section with only one rod, the "2" against the next one, and so forth.

A GAME WITH MONEY

About this time, or perhaps a little earlier, it is well to begin to teach a child the significance of money. He is always interested in this, and will play with it endlessly, and study the possible combinations to be made with it, if they are suggested to his mind. It is better, if possible, to have new money. If this cannot be managed, the coins should be thoroughly cleansed before the child plays with

them. The mother should teach him the names of the different coins with the same three steps used in teaching him the names of the letters and numbers; that is, first tell him the names, slowly, one or two at a time; then ask him for a given coin; then point to a given coin and ask what it is called. At first the little child likes, as a rule, simply to sort out the money into the right piles, all the pennies together, all the nickels, all the quarters, etc.

ARITHMETICAL GAME WITH COUNTING STICKS

An interesting "game" which can be played with numbers, if there are two or more children together, is the following: A certain number of the counting sticks, or any other objects such as clothespins, stones, spoons, coins, etc., are placed on the table. The mother then holds a bag containing the numbers up to ten. Each child draws a number at random, and, without showing it to his companions, goes back to his seat. When all have drawn their numbers, each child goes up to the table and selects from it the number of objects corresponding with the number hidden in his hand. He carries these back to his place and arranges them in order, and waits for the mother or teacher to come and verify the correctness of his counting.

TEACHES SELF-CONTROL

This simple game, which would not amuse older children for a moment, is of inexhaustible interest for little ones, and has a various and complex influence on them. There is a considerable amount of self-control involved in their taking only the number of objects indicated by the number they have drawn, since every child's instinctive action is to grab all he can hold and carry off his prize in triumph. The mother should explain that this spoils the fun of the game, which consists in fitting the mysterious written sign to the number of objects chosen. Another conception which is firmly settled in the child's mind by this and other similar "games" is the abstract idea of "zero," since the child who draws zero selects no objects at all.

GAME WITH SANDPAPER NUMBERS

Another arithmetical game which can be played with one or many children is played with the sandpaper numbers, or any large numbers, such as could be cut out of old calendars. The mother or teacher holds up a number and says, "Come and give me this many kisses," or "Bring me this number of pennies."

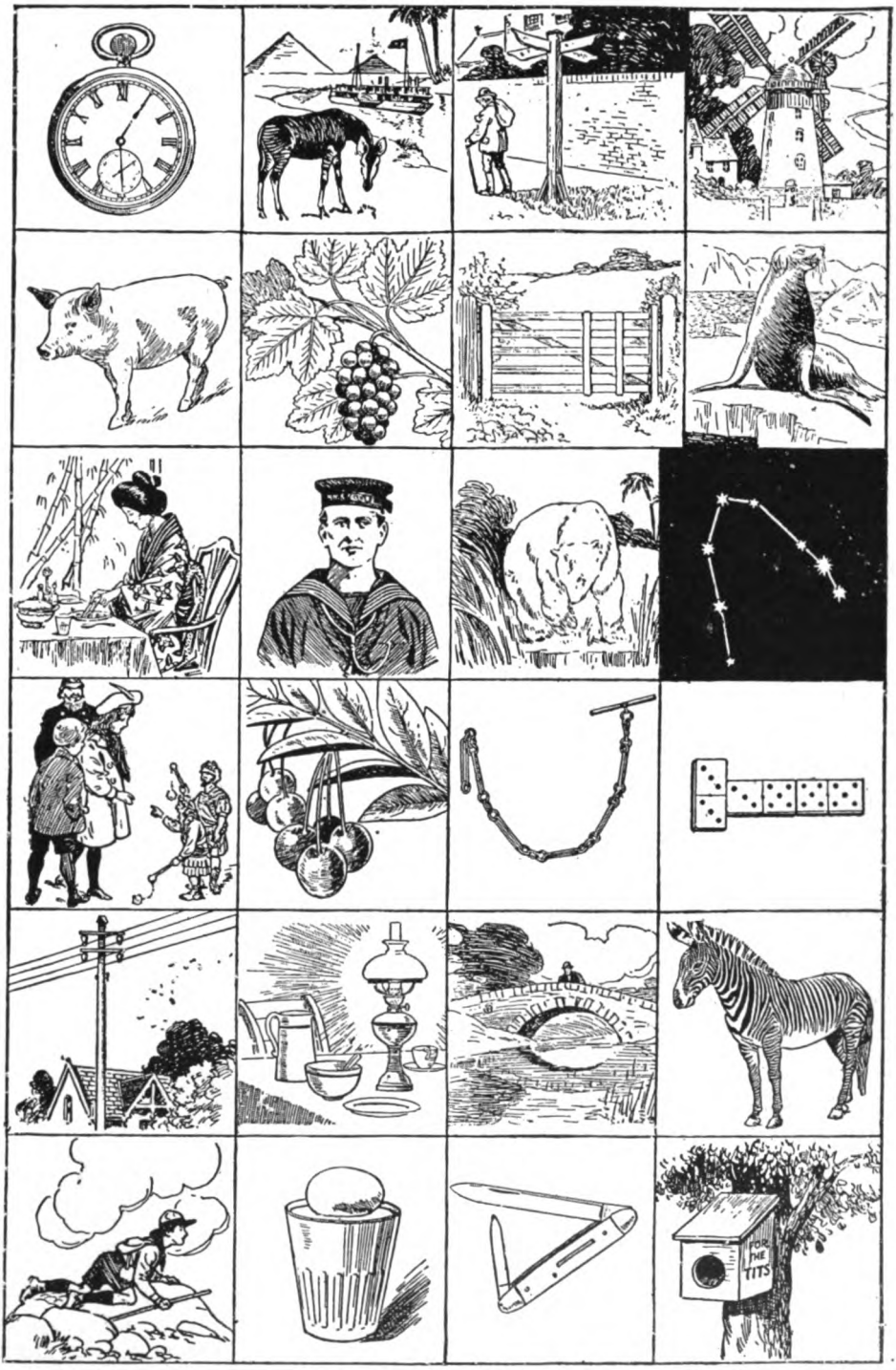
GAME WITH MOVABLE ALPHABET

A similar game can be played with the movable alphabet, with older children, who have learned the beginnings of reading. The mother constructs the word, say for instance, "pin," and, pointing it out to the child, says, "Bring me this, please." The child who is first to read the word and select the article, wins. When several children of the same age and acquirements play this together, the fun, and intensity of interest, and consequent sharpening of wits, form an invaluable exercise.

HIDE-AND-SEEK WITH MOVABLE ALPHABET

A game of hide-and-seek can also be played with children who have begun to recognize words formed with the movable alphabet. The mother constructs, in different parts of the room, different simple words which the child has already seen, such as "pig," "hen," "dog," etc. The child is out of the room while this is being done, and is called back to be told, "I hear something grunting." He then rushes about, peering under the chairs and on the table and window-sills, rejecting all other words he finds, until he comes triumphantly to "pig."

WHAT IS WRONG IN THESE PICTURES?



In each of these pictures the artist has purposely made some mistake. Look at the pictures carefully, and see if you can discover what the errors in them are.

DISCIPLINE AND OBEDIENCE

There is one phase of the Montessori idea which needs more explicit expression than it is apt to get in general descriptions of the system. That is the question of discipline and obedience. Those two subjects are so vital and so tragically misunderstood by most of us, that it may be well to go a little more deeply into the discussion of them.

INTELLIGENT OBEDIENCE

The first thing to do, in the consideration of the obedience of children, is to differentiate clearly in our minds between the obedience that is desirable for an animal, and that which is desirable for the young of the human race. We are apt to be confused here, and to have a misunderstood notion that children should obey, unquestioningly, passively, with no volition of their own, as does a well-broken horse. But such unquestioning obedience, as a moment's reflection will show, is a very dangerous mental habit for a child to acquire, as well as a very difficult one to force him to acquire. The horse may obey unquestioningly some human being; he will always have some human being set in authority over him. But in a very few years, as human life goes, the child will be grown; will no longer be subject to the authority of parents, and must in turn be able to secure the obedience of others. It is essential, therefore, that he shall begin to be a human being—that is, to obey intelligently—as soon as possible. What do we mean by the phrase "obey intelligently?" We mean he must obey, not because some one has told him to and will punish him if he does not, for that is the obedience exacted of the animal; but he will obey because the command is a reasonable one, which his reason tells him it is necessary to obey.

THE BASIS OF PARENTS' AUTHORITY

Our children should understand that their duty is not to obey our personal wishes, because we happen to be their parents, but to obey eternal laws which we represent and expound and enforce. To take an instance, familiar to all of us, which comes into our everyday experience: Children should not, any more than they can help, be "messy" over their meals; should not spill food on the tablecloth, or on their clothes, or be unpleasant in their way of eating. Why should they not do these things? Simply because their parents forbid it? Not at all. Because it is their duty, as members of a community, to make the common life as agreeable, as easy, and as economically conducted as possible. Their parents' duty is not at all to cry, "You do it because I say so!" but to explain reasonably the underlying grounds of conduct, to allow a reasonable time for an understanding of the principle to reach the child's brain, and then to be unflinching in their police duty of enforcing obedience—obedience not to themselves, but to a law, which they must obey as well as the children. If there is no such general broad basis for a command given to a child, it is an unjust command, and should not be issued. No child should be forced to obey a whim of the parent, but only, some modification of one of the general laws which he will need to obey when he is grown up.

THE MANAGEMENT OF THE VERY YOUNG CHILD OF UNREASONING AGE

Now, of course, it is impossible for very little children to make this distinction. Babies under eighteen

months must be forced to obey, if the occasion rises, as other little unreasonable animals are forced, by sheer physical compulsion. But, as this is a very bad method of obtaining obedience, the occasions for requiring obedience should be sedulously avoided, as much as is reasonably possible, during this animal-like period of the child's growth. No one thinks of requiring obedience of a week-old baby, and yet he is in many respects just as capable of being obedient as many a year-old child.

In general, with very young children, the method of procedure should be to so arrange their lives that there shall be few needs to issue commands. A child who is kept quietly at home, playing with objects designed for his use, who is not "shown off" to adults, who is not forced into such cruel situations as enforced participation in adult life, like traveling on the cars, going to church, or to shops, or on the street cars, or asked to entertain a company of idle elders, will rarely be insubordinate or think of such a thing as disobeying for the simple reason that the things asked of him are within his capacity to do. On the rare occasions when such a crisis arises, it is best frankly to treat the little creature like a speechless animal, which he is, and enforce obedience to something necessary.

As soon as he begins to be able to understand simple statements, the reason for various commands given him should be explained to him. One result of this rule is apt to be that fewer commands are given, as they are often seen to rest upon utterly unreasonable grounds. The child should be trained, first, to obey promptly, and then to expect an explanation of the action. In most cases this careful clarifying in his mind of the grounds for action, results in a most satisfactory régime of reasonableness. Suppose, for instance, that a child is seen climbing upon a chair before the side board in the dining-room. His mother should not call out to him simply, "Come away from there!" but should explain to him that it is dangerous for him to handle the glasses, standing in rows on the top, because he would be apt to break them. If the child then asks to be allowed to play with the spoons in the drawer, there is no reasonable grounds for refusing that request. He has made a concession, and has learned self-control and obedience in refraining from touching the glasses, and his mother has, if she is alert-minded enough to learn a lesson, taken note that her command, "Come away from there!" was not exactly fitted to the case. She should have analyzed the situation more acutely, and see that she need not forbid a harmless amusement to the child because it happened to be in proximity to a potentially harmful one. Such frank explanation and mutual concession are most valuable and vital elements in the harmonious relations of parent and child, and do more than anything else to prevent that bitter rebellion against authority which so often saddens the adolescence of children with strong wills and a keen sense of justice.

The mother should make the most careful distinction between the conscious, willful action of a child, and the sort of wild irritability which results in "naughty" actions, but which is the result itself of nervous fatigue, due to injudicious treatment. In the Casa dei Bambini, on the very rare occasions when a child is "naughty," he is treated as a "sick" child; is put off in a quiet corner of the room, allowed all the toys he wishes to play with, is soothed and petted, allowed everything but (this

is the important point) to play with the other children. In a short time this reduces the most unruly child to submission. But in an ordinary home, with only two or three children, the "naughty" child is not privileged, like the Italian child in the Montessori school, to see constantly before him the precious example of the orderly, peaceable, industrious behavior of thirty other children. The principle, however, holds. Nine times out of ten, the "naughty" child *is*, in all sober reality, a sick child, or at least a very tired child. It is hard for adults to realize what a nervous strain it is, for instance, for a child of three to see strange faces for a few hours.

SHOULD NOT DISCIPLINE OR TRY TO REASON WITH A CHILD WHEN NERVOUSLY EXCITED

The only thing the mother can do in such a case is to remember that the child is not himself when nervously excited. There is no use trying to "reason" with him, or to discipline him, or arouse his better nature. For the moment he *has* no better nature! He is nothing but jangled nerves. A tired or excited young child should never be asked to exercise self-control; there should be no occasion for it. The only thing to do with him is to quiet him as soon as possible by purely physical means. If he is hungry, get him something, very easily digested, to eat; slip off his clothing, give him a warm bath, if possible, and lay him down in a comfortable bed, in a room not too light, with *plenty* of fresh air. When he has slept and rested, he will have "come to himself," and the necessity for punishment will be past. He will, as he always does when he is in good physical condition, *desire* to be a good child. There will be something there for the mother to work with. Even if he has had no special excitement, there may be times, in the life of an especially nervous child, when his vitality is at a low ebb, and the regular routine of life is too much for him. If he shows signs of nervous irritability, snarling and snapping, or crying at nothing, he should never be reproved. He should be put to bed, not at all as a punishment, but with the tenderest affection and the most solemn pity for the poor little sensitive creature. If there is in this prescription of rest for nervous fret, no hint of punishment or shame the child will not resent it, but will soon learn to yield himself up to the soothing influence.

HOW TO AVOID A "BRAIN-STORM"

If, when several little children are playing together, the mother hears one begin to speak in a loud, excited voice, and to have nervous, disorganized motions, such as knocking the playthings about, she should come up quietly to the group and remark calmly that "Johnny is evidently too tired to play any longer. He'd better go and rest for a time, until he feels better." Then he is led away, very gently. There should be the utmost care not to seem to use this as a chastisement. His face and hands should be washed in cool water (there is very apt to be a slight fever present when nervous irritability sets in), his clothing loosened, and he himself laid on a bed in a quiet room. This treatment has, in addition to the invaluable physical effect, a very strong moral one. The gentleness, the peace of the room, the utter isolation, the inaction—there seems nothing left for the child to battle with, nothing for his "naughtiness" to feed upon.

Children do not enjoy the miserable unhappy excitement of being naughty, no matter what our misunderstanding reading of them may seem to indicate. And if they have had a fair experience

of a sure escape form the "brain-storm" of a fit of insubordination, they are very apt to resort to it of their own accord. If it is evident that the child cannot be sleepy, for instance, only a short time after a nap, another calming expedient is to take him gently away from the others to a quiet place outdoors, where he is left to play in solitary proximity to the bosom of Mother Earth.

But of course this remedy cannot be applied, if the nervous fit comes on while the mother is pricing lace in a department store and the child hanging to her skirts, or if they are at an "amusement park," with bands braying and tooting about them, and crowds of excited pleasure seekers noisily going their way.

This is another reason for never taking children away from the quiet home life, except to some equally quiet spot out-of-doors.

This rule may be relaxed, of course, as the children grow older, but it should be relaxed very gradually, with the fewest possible breaks in the tranquil and unchanging life.

NECESSITY FOR CONSTANT ACTIVITY IN EARLY CHILDHOOD

The final lesson we American mothers have to learn from Dr. Montessori and her wonderful success with the training of little children, is the lesson of positiveness, as opposed to negativeness in their lives. The craving for constant, unceasing activity in little children is intense. This is a normal and blessed instinct of theirs, which does more than anything to develop them. And the mother should constantly bear it in mind. Her attitude towards her little child should be as little negative as may be; she should set her grown-up wits incessantly to work to devise wise, harmless and beneficial actions for the child, not merely to forbid him unwise and harmful ones. And here the Montessori apparatus is of incalculable value. It caters with scientific ingenuity to the need for action of the small child, and relieves the mother's inexperienced brain of a great part of the strain of inventing suitable exercises for children under six or seven.

MONTESSORI APPARATUS NOT ENOUGH

But the Montessori apparatus, valuable as it is, is not enough. As has been said many times in the preceding pages, the mother's mind must be alert and ingenious to supplement it as the child grows. For instance, blunt pointed scissors and plenty of paper to cut are as indispensable as the geometric insets. Constant exercises in the occupations of everyday life, such as washing and wiping toy dishes and setting a small table, sweeping the floor with a small broom, learning to dust, etc., are as necessary as the sandpaper letters. If the children are initiated into these exercises young enough, before their natural instinct for action and for helpful action has been atrophied by the customary idling in early childhood, the mother will find the utmost eagerness for such activities, and not at all the lazy, shirking attitude towards them so frequently seen in older children, who did not have proper training in their early life.

The other kind of obedience, the right kind, can be attained only very gradually, for it is at least as difficult an achievement as learning the multiplication table. The child needs to begin with very small beginnings in this as in any other important activity of his life, to be asked in early childhood to obey as seldom as possible, because his life is rightly and carefully suited to his needs; to have the reason for obedience; the real, underlying philosophic reason explained to

him as soon as possible and as often as necessary; never to be asked or expected to obey when he is having what amounts to a fit of hysteria; and, finally, to have his life so filled with interesting, profitable and entertaining occupations that the question of obedience enters into it very little. Through the daily experience of living a well-ordered, industrious, purposeful life, he learns, unconsciously the joys of peace and tranquility, and he comes to be as unwilling to wreck these by insubordination as his mother is unwilling to have him.

Like any other good *habit*, obedience cannot come from one or two violent efforts. It must come from a long, long continuance in the right conditions. And to secure these "right conditions" the Montessori apparatus, method and philosophy are the most potent means as yet discovered.

MEMORY TESTS ON MONTESSORI SYSTEM

What facts about children did Dr. Montessori rediscover?

What is the most important principle of her Method?

What three principles may be said to sum up the Method?

On what principles can children learn without detailed instruction?

Why should the five senses be carefully and directly trained?

What is a Casa dei Bambini?

Will little children learn useful things if not forced to stop playing?

Why is spontaneous attention better than forced attention?

Is it well to help the child with his Montessori problems?

Do little children as a rule learn best through the eyes or through the fingers?

What are some of the essentials for teaching system and order?

Why should a child learn to dress and feed himself as early in life as possible?

Why should the little child not be hurried?

Why is a very large rag doll to be especially valued as a play-thing?

Should little children be allowed to handle or play with small objects?

How can children be taught to "see with the fingers"?

What are some of the advantages of learning to do things by touch rather than by sight?

Does Montessori freedom for the child mean upsetting all order in the household or schoolroom?

Why the child needs training in bodily poise and how this can be obtained.

Should children be allowed to play with water? How? Why?

Should little children do housework? How?

How should the alphabet be taught?

What are the three signs by which a Montessori mother or teacher can tell when the child is nearly ready for the explosion into writing?

Should a little child have pets of his own?

What is meant by a "Montessori scheme of existence" for little children?

Should a child's life have some unvaryingly regular events?

Under what conditions do little children take an interest in arithmetic?

How should the numbers be taught?

How can arithmetic be taught by means of games?

How can the Montessori game of "Making the Silence" be duplicated in the home?

Why should a child practice exercises in immobility?

Why should a child's actions about the house be as free as possible?

How can ordinary incidents in home life be turned into Montessori exercises?

Should little children be allowed to play with books? With delicate breakable objects? Under what conditions? Why?

Should a little child use a tin, a silver or a china cup?

ABOUT OBEDIENCE AND HOW IT IS OBTAINED

What should a mother always add to the command "Don't do that"?

Why should the little child be trusted as much as possible?

Should a child be taught to obey as is an animal?

Should children be forced to obey commands based on personal wishes of their parents?

Why should children always feel that they are obeying a law, not an adult's whim?

How can unreasonable commands be avoided?

Under what general conditions of life is the question of obedience simplified?

Why is there need for clear thinking in issuing commands for children?

Under what conditions are "naughty" actions not punishable?

Why is it important that the child's natural impulse to see and to do things should not be suppressed?

How does the Casa dei Bambini inculcate absolutely quiet life for young children?

How treat a nervously exhausted child who is acting as if it were naughty?

THE SCHOOL OF REAL LIFE

WHAT A BOY MUST DO TO SUCCEED

EVERY boy looks eagerly forward to the time when he will be a man and will struggle for the prizes that are offered to men in the big world. Every man looks back to the time when he was a boy and feels that if he had a chance to try it over again, he could avoid many mistakes. In America every boy has great opportunities for success. With good health, and energy, and honesty, any boy may work his way to a successful career.

But the mistakes which a large number of boys make when they begin to work for themselves, the numerous blunders and failures among men, prove beyond question that real success in life's work is not easy, and is not to be had for the asking. It is not by plunging in recklessly and carelessly that men succeed, but by wise forethought, by faithful attention to business, by honesty and reliability.

In our time we are talking much of the vocational training of boys, that is, of a special training for business or trades and professions. The common school gives a general education, but does not prepare boys for special callings. Before trying one's chances of success in the big world it is well to take advice of older people who have had experience, who have suffered the hard bumps and discouragements, and can give boys good pointers as to how to conquer success.

That boy is most likely to win a place for himself in life who is willing to take advice, who will train himself thoroughly, who is not in too big a hurry to start out in the world, but first gets a good education, and if possible trains himself well for some special calling.

THE SCHOOL OF REAL LIFE

Life itself is a great school, and when we get out into the busy work of the world, we shall have plenty to learn. New problems and difficulties are coming up all the time. From the very start we must learn how to meet and master hard problems, to do disagreeable things, to stick steadily to what we undertake in spite of difficulties and discouragements. This big school of life is like all other schools—full of wise or unwise scholars. There are some who go through it day by day, week by week, year by year, as if life did not matter, waiting always for play-time, caring nothing for the things for which schools were made.

It is these students who keep down the proud reputation of the school. It is these, in the big school of the world, who are responsible for most of the misery and trouble of mankind.

Nothing can keep the boy back who means to go forward. The roads that lead to success in life are widening more and more. One may wander in a hundred fields and pick his prize. But no boy can get any farther than he aims. He must make up his mind where he is going and must remember that it is not only the way he goes that matters, but how far he goes that way; whether, when he has chosen the way, he quits himself like a man. He must remember that all useful work is honorable, and that the only dishonor in it is if it is badly done. And the task that is set before every man is, not to be this, or that, or the other—to mind a machine, to drive a plow, to write a book, to paint a picture; the great task set before a man is, so to prepare himself in youth that in carrying on his work in the world he shall do all things well.

THE QUALITIES THAT COIN SUCCESS

What, then, are the qualities that we need most on our way through the world? There are few things that all men agree about, but some things there are that every man knows to be true. And perhaps the first of these things is that to do anything worth doing in the world we must have a definite purpose. We must have an aim in life. We must make up our mind what we want to do, how we want to do it; and we must let nothing come in our way. We must think of time as what it really is—a treasure given to us for our safe keeping.

Time, it is said, is money. But time is much more than money, for time can do what all the money in the world can never do. Time can heal all sorrows and cure all ills, and time, if it is rightly used, gives opportunity too great to be realized by the young. Time spent in watching others play games, or in idling on the street is lost time. We do not want forever to be bent on serious things, and there is time for all of us to play; but nothing is so dangerous as amusement, and we had better never play at all than let play steal away our lives, and lead us to forget our aims.

And a boy must have ambition. He should not believe those who tell him there is anything wrong in the desire to get on well in the world. There is a right getting-on and a wrong getting-on, and when we say that we want to get on I hope we always mean, not merely that we want more money in our pocket, but that we want to know more as well as to have more; that we want more opportunities of well-doing and well-being. There are low ambitions and high ambitions. Let us see to it that we aim at a high purpose; that in Emerson's splendid words, we hitch our wagon to a star.

We must be resolute; we must have determination. It is no use having ideas unless we mean to carry them out. One other thing goes with determination, and that is concentration. One may have great energy, and may put it all into his work, but may use his strength in such a way that it simply fails. Everyone knows what a spendthrift is—the foolish man who throws away his money in stupid ways which serve no purpose instead of keeping it for something that is worth doing. Stick to the work—that is what is meant by concentration. It is wrong to try to do so many things that none of them can be done well. Time is wasted that is frittered away in little things that make no difference to anybody.

The boy who sticks to his work—that is the boy the world is waiting for. That is the boy who will paint the picture that everybody will go to see. That is the boy who will be manager of a big business. That is the boy that every mother wishes her son to be.

There are plenty of other boys; plenty of boys who will grow up to sell matches, or newspapers, and to do nothing particular for anybody, and worse than nothing for themselves. But the boy the world wants is the boy in earnest, the boy who is ambitious, the boy who is determined, the boy who will "stick to it."

THE USE OF DIFFICULTIES

It is often said in these days that life is made too easy, and that, because we have no longer to fight for our birthright as men fought in other days, we are not so strong and ready and daring as those who lived in harder times. There is just enough serious truth behind that to make it difficult to contradict, because life does, of course, become easier and happier as knowledge grows. If it

did not, knowledge would not be worth having. The things that do not help us to live are not worth learning.

But it is not really true that life is becoming so easy that character has no chance to grow—which is what people mean when they look back and sigh for the good old times to come again. There never was such wicked nonsense as the talk about the good old times, and the man who sighs for them back again does not know what he is sighing for. There never were such good times as these in which we live. There never were such bad times as those that have gone. In the good old times little boys were forced up chimneys and down mines, and little girls were whipped to work in factories. That was one way of making them strong, but the pity was that most of them died without finding anything worth being strong for. Nothing can be more wicked than to wish for the dark, ignorant, cruel past to come back again.

Those who talk in this way imagine that character grows best in hard ground, and that therefore life must be made hard and cruel, and boys must be buffeted about, and perhaps beaten, or at any rate in some way brought to feel the cuts and blows of some outrageous fortune. The great untruth behind all this is the idea that cruelty is necessary to breed strength, that hardship is necessary to develop firmness, that we must make difficulties in order to develop the power of overcoming them.

It is true that overcoming difficulties is a fine way of growing strong, but it is true, also, that life is always difficult enough to develop the highest strength of character. In the great training grounds of the world the noblest human qualities can always grow, and life can never be so easy that one need fear he will lose his character, *if he wants to keep it.* The difficulties of life do not disappear; their nature changes—that is all. The boy who is going to make his mark in the world, however pleasant a place the world may be when he grows up, will find difficulties to overcome.

There will always be a world to conquer, and nearly always it lies about one, perhaps nearer than one's own door. The boy who gets over difficulties must make up his mind, at the very beginning of anything, what it is he wants to do, and having made up his mind, he must do it. He should let no difficulties turn him back from the way he should go. Only cowards count the cost of doing right, and shrink from it. The thing that is easy is there for anybody to do; it is the brave boy who will tread the difficult way, who will run a risk, and do the hard thing. There are people in the world who think it right to go through life taking all that life can give them and giving nothing in return; but they live their selfish lives and pass away and are forgotten. Out of their ranks no hero comes.

It is perfectly true that where there is a will to do a thing the way to do it can be found. A story is told of how Alexander the Great arrived one day at the city of Gordium, and found there a famous chariot fastened with cords tied into knots that no man could undo. And Alexander was told of the legend that whoever should untie the knots should rule the world. It was not like Alexander to waste his time untying knots, but he found a better way. He cut the knots asunder with his sword, and ever since the man who chooses the bold way out of a difficult situation has been said to cut the Gordian knot.

It is right to be cautious but it is wrong to be cautious even to timidity.

The world is not in want of men who will hold back. They are at the corner of every street; every town is full of them. It is the boy who will go forward that the world is waiting for—the Columbus, the Washington, the Livingstone of the future.

THE GLORY OF COURAGE

What the world needs is the courage that climbs over mountains or cuts them through, the boldness of a man who, knowing what is to be done, sees the difficulties and conquers them. We would not be living in a free country, the land we live in would still be overrun with barbarism, if men had chosen the easy way. One has only to think for a moment of the things which every boy knows to see the spirit that conquers the world. Such a spirit was that of Columbus at the court of Spain, fighting against prejudice and ignorance and blindness until his courage moved a queen to pledge her jewels for the expedition that was to discover America. It is the spirit that General Grant displayed in his military campaigns, that remarkable persistence and steadiness of purpose, which never faltered, and wrought out his great victories. David Livingstone shows this spirit, poring over his books till midnight, getting up at six o'clock in the morning, and working in the factory till eight at night, going to school from eight to ten, then poring over his Latin grammar again as long as his eyes would keep open, and then sleeping till six o'clock brought back another day. He worked half a year in the factory, and spent his wages in the next half at the university. He never met, either then or as a man, any difficulty that he allowed to stand in his way. His stubborn will conquered the hot fever-laden climate of Africa.

At a time when all America was talking of Mr. Roosevelt, an American paper said jokingly, "Just stop to think that Theodore Roosevelt is only one nine-hundred-and-forty-thousandth of one per cent of the population of the United States." But it was the genius of Mr. Roosevelt that he would not let America think that. The man who means to have his own way may count only one in the census paper, but he may count a million ones in history.

All things come to him whose spirit will not die. The men who have transformed the world—what sort of lives were theirs? They read their books by candle-light and lived in garrets, they toiled long hours down in mines and rarely saw the sun, they prayed in vain for one word of sympathy; for the bold man with the new idea had all the world against him until these modern times.

It is hard to believe the difficulties that were put in the way of men who looked into the future years ago, and laid the foundation of comfortable lives for those who live now, and of prosperity for nations.

Robert Fulton, the man who made steam navigation a success, was scoffed and jeered at on every hand; not one word of encouragement, not one bright hope, not one warm wish crossed his path, he said.

George Stephenson was denounced as an impostor when he began to make his railways; and one of the saddest things in the history of any nation is the story of the bitter struggle to save the little children of England from slavery. They were whipped to work like dogs, until so many died that they were buried in secret to hide the awful truth.

Times have changed, but still it is true that the path of the good man through this world is strewn with thorns. Men have so much to do, and so little time, and so many things to

bother them, that it is hard to interest them, and harder still to get their help; and so we are discouraged and downhearted, and noble causes lag for want of friends.

It is always so. But the boy should arm himself in the days in which he is putting on his strength against the disappointments that must come into his life. They will come, whatever happens, and at times it will seem to him as if the sun had gone out, and as if nothing matters and nobody cares. But he will remember that, however dark the clouds are, the sun breaks through again. He must not let despair seize hold of him because the task is hard and there seems to be no way out. He can sustain himself by the proud thought that he is in the line of heroes. Behind him stand Captain Scott and David Livingstone and George Washington and Abraham Lincoln and Francis Drake and Joan of Arc, and he will not shame these mighty names by turning back.

The thing that is in the way is the great test, the touchstone of an enterprise. Two boys meet a difficulty, and it is like the instrument at the mint which touches every sovereign, throwing out the bad and keeping the good. One boy turns back, but the other is true as steel. The fear of danger, the sight of a mountain, the touch of risk, the wondering whether he will really manage it, are new life to him. He goes on with new zest and resolution, and almost before he sees the difficulty it has gone. Like melting snow difficulties go when a brave heart comes along.

Especially must he be on his guard against the difficulties that do not exist.

Some of your hurts you have cured,
And the sharpest you still have survived;
But what torments of grief you endured
From evils which never arrived!

Half the people in this world spend half their lives in wondering how they will get over a stile that they will never reach. One of the wisest things ever written in a copy book is, "Do not meet troubles half way." Time is too precious to spend in imagining difficulties; they will come soon enough.

Even wise men are wrong sometimes. Perhaps you have read how, in the early days of railways, men spent their time in trying to get over the difficulty of making a smooth wheel ride over a smooth rail. The wheels would skid on the smooth lines, it was said, and for years men saw no way out. Then at last, somebody tried a smooth wheel on a smooth rail, and found that the difficulty did not exist.

Only a great daring, an inflexible purpose, an unquenchable spirit of perseverance, can rouse the world from its indifference and drive away defeat. In little things and great, in the trials of our own lives and in the public things we fight for, we must dare to do right, whatever the consequences may be.

He either fears his fate too much,
Or his deserts are small,
Who dares not put it to the touch,
To gain or lose it all.

There are nobler things than boldness, there are baser things than fear. But there is nothing sadder than the fear of doing right; there is nothing nobler than the fear of doing wrong. Let that be the only fear. Let the soul be pure, let the heart be brave. Be strong and of good courage. He that overcometh shall inherit all things.

WHAT A GIRL MUST DO TO SUCCEED

YOU are sure to be wondering, as you stand at the gates of Life and look out upon the world, what destiny the hidden years can hold for you. As surely as the leaves fall, in obedience to the Hand that guides the heavens, so surely your unfolding life is dawning, and will rise to noonday, and will sink into the gentle sleep of night, to the bidding of the universal law that none can break.

But because your life is part of the great world you will not believe that therefore it is fixed for you, so that you have no choice. You are free to do as you will. You are free to use your life or to waste it. In the great scheme which even now is building up a perfect world, your life must have its place. But you are not a spectator looking on at the world. You are an actor, taking part in it, and the great play of Life will fail so far as you fail in your part.

And you are wondering, no doubt, what part you will play—whether you will go out into the world to do great things, or whether you will be content to be of the multitude which moves in quiet paths, doing good without ceasing, making life a blessing, but winning neither wealth nor fame. And you must resolve for yourself the question that every girl must ask herself—whether you will seek first the natural place of woman in the home, or whether, in some wider sphere, you will seek to carve out an independent place. It is the most important thing you can decide, and nothing can be more difficult than to advise you.

USE OF NATURAL GIFTS

But of one thing it is easy and right to advise you. You can do no wrong in putting your natural gifts to any natural use. You can do no wrong in fitting yourself for any office you can fill with profit to yourself and usefulness to others. You can do no wrong in choosing any path that leads you to your destiny with dignity and honor. But you may do yourself great wrong, and may betray the cause that every woman holds in trust, if you cut yourself off, knowingly and purposely, from the noblest work that daughters and wives and mothers are called upon to do.

You are growing up in an age when too many people are willing to sully the fair fame of a woman. Of all the sad things that happen in these days, nothing is sadder than the things that make us forget for a moment the gentleness and graciousness of womanhood. It is a beautiful vision that comes to us as we think of our mothers, and of their mothers, and of mothers all down the ages of time; but how easy it is sometimes to forget the things that make the thought of women so comforting and uplifting! You will have nothing to do with the vulgar manners you will see about you, with girls who would be men, forgetting how much greater than men they could really be. When you find yourself in the company of a girl who smokes, keep your modesty and leave her; she is not going your way. In such small things begin the end of modest girlhood. The manners of men are not for girls to put on as they put on hats and gloves.

The men for whose esteem a girl should crave have no esteem to spare for girls who ape their habits without thinking, who break through the fine reserve that is a girl's best safeguard, who mix with men and come down to meet them, when men instead should rise to their higher level. All through the world, and all through life, the *something better* in a woman has been

the world's great blessing, and nothing that the world can give will be worth having if you lose this priceless thing.

Whatever way you choose through life, you will guard the noblest thing your mother gave you—the charm of being made in her own image. You will cherish the thought that the love for a mother is the strongest influence in the world, and you will do nothing to wreck the place a mother holds in the deathless affection of mankind.

THE GREAT POWER YOU WILL HAVE TO STIR MEN TO GLORIOUS THINGS

You will not mind the scoffing of those who are careless in small things; you will be ready to give up lawful pleasures rather than run the risk of losing the fair name which is worth more to you than rubies. The knight's armor, in the days of chivalry, was buckled on by his lady, and the beautiful meaning of that should still be true in these days. It was the gracious way in which a lady sent out her knight to fight with double strength.

This is the great power for woman still, so long as she keeps her hold upon her knight. The things that are unseen are hers, the influences that reach deep down in the heart of life, and never wholly fail. How often it is that the man who seems so powerful, who seems to do as he likes and to conquer wherever he goes, is really swayed by a great love behind him, and nearly always the love of a woman.

A BLOW THAT YOU MAY STRIKE AT A WRONG VIEW OF LIFE

You may be rightly proud of the gifts which enable you to win your own way in the working world, and there is no reason anywhere why you should not place yourself by the side of men in any sphere in which you can hold your own. So long as your work fits you, *and does not unfit you*, for your natural destiny, it can be nothing but a blessing. It can bring you nothing but happiness to be conscious of a power to face the world whatever happens, and in the years when you are building up your life you may wisely seek the discipline and training of some useful service. The useless have no rights, and we must be useful. Even though your lot be cast in pleasant places, so that you may not need to earn your living, it will do you no harm to do some useful work. The real wages for good work are not made at the mint.

The girl who wins a place by her own efforts has strengthened herself in any task she undertakes. She has struck the hardest blow she can at the silly notion that woman must be a sort of on-looker at the world.

THE GREAT TEMPTATIONS THAT WILL COME TO YOU TO WASTE YOUR DAYS

Thousands of lives have been saved from ruin by a definite work in life; thousands have been wrecked by the want of it; and nothing will more likely prepare you for the coming years than a definite piece of wisely chosen work, whether for wages or for love of doing it.

"Our time," said Sir Walter Scott, "is like our money. When we change a dollar, the dimes escape as things of small account; when we break a day by idleness in the morning, the rest of the hours lose their importance in our eyes." Idle hours are temptations, but idle years are worse, and it is not surprising that the end of nothing-in-particular-to-do for years should be a consuming love of pleasure. And then often in its train comes the sad waste and vanity of it all—the love of vain things.

THE EMPTY VANITY THAT FLAUNTS ITSELF BEFORE THE WORLD

We need not object to anything beautiful, but the vanity of riches is not the love of beauty; and the things that

are worn because they are ticketed at a high price in a shop, and so advertise the splendid incomes of those who wear them, are not things to admire. You will learn to love things that are really beautiful, to prize things that are really valuable, and you will scorn the empty show which flaunts itself so much before the world and has nothing lovely or noble, or really worthy behind it.

Life is not simple, and it is not easy always to know what to do; but it will help you, now that you are wondering which way you will go, if you make up your mind to go the simple way.

THE GIRL WHO LOVES HER HOME

You have learned that happy homes are not made with hands. The foundations may be deeply set, the great walls may rise high and the windows may look out upon a noble scene, the room may be rich beyond avarice and beautiful beyond compare, and there may be nothing wanting to please the stranger's eye; but the seat of happiness is not in these things. If one invisible thing is absent no visible splendor can atone for it; nothing that we can touch or taste or hear or see can help us if this thing is missing. Every day, for want of it, homes are wrecked and lives are broken.

You will guess that this invisible foundation of a happy home is the love of those who live in it. Love and happiness run together. There can be no transgression of that law. Whatever else is false this much is true, that hearts divided against themselves can never make a home. And so you will resolve that your home shall be built upon this firm foundation.

And so you will feel that your home is the shrine of sacred things, a field in which the seed you sow may grow into a precious harvest.

You will think of your home as your own little corner of the world, where you are queen and you will set your influence as on a rock. You will love your friends outside your home, you will cherish goodwill to your neighbors, but within the walls of your own kingdom you will give yourself unselfishly and toil unceasingly for those who are banded together as one, heart of your heart, mind of your mind, life of your life, traveling beside you through sunlight and shadow, through ill and good report.

THE LITTLE WORLD IN WHICH YOU WILL MAKE YOUR OWN LAWS AND KEEP THEM

We are in the world and of the world, and we must take our place and play our part. If we could rule the world for just one week, we have thought sometimes, how happy a place we would make it! Well, our homes are our own worlds, in which we make our laws and administer them, in which we lay down our rules of life and declare our relation to our neighbors and mankind. Your home will be the place where you find rest, but your rest will bring you new strength, and you will spend it for the good of all.

THE QUALITIES THAT ARE CALLED FOR IN MANAGING A HOME

Nothing in the world, perhaps, is more difficult than the wise management of a house. Most of us are too ready to forget, in enjoying the great freedom of home, that a home is like a machine, and must have method and discipline if it is to have peace. It is a wonderful thing, considering the millions of opposite interests in the world, and all the selfishness and indifference, that the world agrees so well; and it is not surprising that the management of a home, with perhaps six people of six different types, with tastes that can vary in perhaps a hundred things, with conflicting desires in food, and pleasure, and friendships, and with varying needs in other

ways, should call for the very greatest care and judgment.

It is not an easy task to control the home-life of a family, fitting all these desires into a general plan, giving freedom and happiness to each and contentment to all, and it is harder still if some break the rules. You will not be ashamed to acknowledge that your place is in the kitchen as well as in the drawing-room. The proper management of a kitchen is one of the greatest services a woman can render to the world.

If we think of the lives of the great multitude of working people, it is easy to see how bad food, bad cooking, bad housekeeping, can spoil them utterly, and we have yet to measure the effect of these things in driving men out of their homes and into public-houses. If it is true that the public-house, with its horrible associations, all its germs of disease, has taken the place of home in the lives of masses of men, who shall say how many of these men turn to such places in search of the comfort missing from their homes?

THE GREAT NUMBER OF THINGS WE CAN DO WITHOUT IN THE WORLD

You will learn very soon, in building up your home, that simplicity of life is the golden key to happiness. It is one of the sad consequences of the progress of the world that civilization brings with it a great increase in what we call our needs, though they are really only our desires. Crave for the things that will make you happy, but do not create unnecessary wants. It is astonishing to think of the number of things we gather into our houses that we do not really need.

THE ENDURING JOY OF HOME THAT COMES FROM SIMPLICITY

Make up your mind that the simpler a home is, the more enduring is the joy of it; the more natural our environment is, the more natural we ourselves shall be. Let us set our faces, in our homes and out of them, against what is artificial and conventional. It is art and good sense to have few things in a home, instead of many, and to have these of the best; and it is good to have them natural, instead of artificial, with some idea in them that helps us, or inspires us, or brings us pleasure. It is good to have real things instead of imitations; it is good to have a few of the very best pictures rather than a whole gallery of meaningless daubs; and it is good to have about us the books that we love. It is good, in a word, to live in a house that seems to be a part of nature herself, helping us in our natural life, and deepening within us the love of true and noble and beautiful things.

THE WISE WORDS OF SOLOMON ON THE WISE WIFE IN THE HOUSE

You will spend these early years, while your own home is still afar off, in fitting yourself for it. You will not be afraid of the great task to which you set your hand. You will know the high mission that you undertake, you will rejoice in the high privilege of building up a home, and you will build it in the spirit of King Solomon when he wrote: "As the sun when it ariseth in the high heaven, so is the beauty of a good wife in the ordering of her house."

THE GIRL IN SEARCH OF PLEASURE

The first duty of a girl, a wise man said once, is to be happy. Unless we can be happy, life is hardly worth while.

That perhaps may seem to you a strange thing because you know of so many lives that are a great blessing to the world, though they may seem to you about as sad as anything can be. And it is perfectly true that noble lives may be full of sacrifice and sorrow; perhaps it is even true that sacrifice and sorrow make thousands of lives noble and useful which but for these

things might be lived in vain. But all through the years that are opening out before you you will find one thing becoming clearer and clearer in your mind; you will find that the pleasure-seekers are not always glad, and the sorrow-bearers are not always sad. You will find that there is a secret of happiness which neither money, nor social advantage, nor education can buy, and which neither poverty, nor sickness, nor other ills of this world can utterly destroy.

And so we learn to understand that there are ways to happiness which perhaps we have not guessed. Happiness is much more than a mere passing sense of pleasure, and we should seek to build up the happiness of our lives on an enduring foundation. No mere round of social pleasures, no mere pleasing things that last for an hour and are gone, can give us that. Pastime has its proper place, and it is true that all work and no play makes Jill a dull girl, but the ordinary amusements of life are not the true source of happiness.

One of your temptations will be to rely upon these things when you should seek enjoyment in other ways, and there is perhaps no greater enemy of girlhood than the ceaseless round of empty pleasures that assail the girl who comes face to face with life on her own account. It is so easy to do this and that, to go here and there, that you are sure to be tempted to give yourself too much to the side of life which is meant only as recreation.

Doubtless you will discover, long before you have yielded to this temptation, that the best way to be happy is to plan your life so that pleasures come into it naturally instead of being outside it, as it were. Nothing could be more unwise than the sort of life some people live, divided into two compartments. One compartment is for work, which we should rather call drudgery, for it brings them no joy and is done against their will; the other compartment is for pleasure, which we should rather call pastime, for it is merely relief from their duller life, and is simply a stupid way of passing time which their dull minds do not know how to use. It is true that some of us must do the duller kinds of work if the world is to go on, and no doubt stitching all day long, or making boxes, or adding up figures, or typing letters are not as interesting as painting pictures, or writing books, or managing businesses; but most of us have no real excuse for not being interested in our work, and it is a sad thing to turn it into such a drudgery that we must seek relief from it at any cost.

THE DUTIES AND PLEASURES THAT WILL FIT IN WITH ONE ANOTHER

You will not fall between these two extremes—the burden of work which bores you and the reaction of amusement which gives you no real compensation; you will make your whole life so interesting that you will not need to pay other people to amuse you in order to escape from it. You will look a long way ahead of you. You will have a definite purpose in your life, and you will see, as far as you can, that its duties and pleasures fit in one with the other, so that they lead and follow each other naturally instead of being like opposite things.

THE COMPANY WE KEEP WHEN WE ENJOY OUR PLEASURES

You would not think of taking certain people home; you would shrink from telling your mother that you had been with them at dinner, or walking with them in the street, or sitting with them by the fire, or talking freely with them. We need not think ourselves better than other people, and it is no hollow hypocrisy, and no sort of priggishness, that turns us from the

company of those whose way of life is not ours. The natural pride of life, the dignity of girlhood, will cause you to shrink from evil things not less if they come in the form of men and women than if they come as serpents, and it will help us if we realize that, whenever we go to see men and women of bad character on the stage, appealing to their audiences by the very atmosphere with which they have become associated, we are *in the company of these people* as if we had invited them to our homes.

You will be on the side of pure pleasures always, but you will hate the vulgarities which pretend to be entertainments, and you will rather die than countenance with your presence some of the shameful scenes that take place openly in theaters and music-halls.

YOU WILL SEE THAT YOUR PLEASURES ARE WORTHY OF YOUR HEART AND MIND

When anything impure is done, or said, or sung in your presence, in public or in private, you will be faced with a problem that you must instantly decide: you will have to stay and lose your dignity, or to go and keep it, and you will go. It shall not be said of you that you stained the fair fame of the people's pleasures by patronizing a hideous thing. You will be sure a play is sweet before you go to see it, just as you will be sure that a man is honorable before you consent to know him.

And, especially you will take care, in choosing your public pleasures, that they are worthy of you in another sense; you will refuse to enjoy yourself at the cost of another's pain. You will be ashamed to think that another human being should imperil his life, or her life, to please you, and you will refuse to be pleased by the sight of other people risking death to earn a living. You will be shocked to think that there should be any pain or fear or sorrow caused to others in order that you might enjoy a pleasant hour, and you will ask yourself what a mother's anxiety must be while her boy, or her girl, or her breadwinner, hangs in danger of death on an iron bar high up in the air; or how little children must live in dread of something happening to their father, who stands in danger every night that you might watch and be excited by his peril. You will love life too much to think lightly of endangering it for others, and you will turn in pity, if not in disgust, from so-called pleasures which involve grave peril to life and limb.

THE TERRIBLE PRICE YOU WILL NEVER PAY FOR THE THINGS YOU WEAR

You will dress for neatness and not for show, and you will not think your hat, or your coat, so important that for their sake you can throw aside your charity and gentleness and love of justice.

You will not think it worth while to starve a family of fellow-creatures in order that you may wear a pretty hat. You would blush for shame if you were asked to wear a thing that had been stolen; how much more then you will blush if you should find yourself wearing one day a beautiful thing bought by torture and cruelty and the wanton shedding of blood! It is right that we should remember the terrible words uttered not long ago by a professor who had been investigating the circumstances under which aigrette feathers are obtained, and who declared that *every girl who wears an aigrette has the murderer's brand upon her brow.* It is a terrible saying, but it is true.

It is enough to say here that an aigrette's feather can be obtained only by the most terrible acts of cruelty that men can inflict upon birds, and that every plume of an aigrette, or a gull, or a bird of paradise, is

obtained by the murder of a mother bird at the time when she is bringing up her little ones, so that she hovers round the nest and is easily caught.

THE GIRL WHO THINKS AND FEELS

You are thinking and feeling about a thousand things in these years in which you are laying the foundations of a world. What a solemn thing that is to say, and yet it is true that every one of us, in the days of our youth, is building a world as certainly as he who builds up stone on stone and crowns them with towers and domes. We come into a world that is open to receive us; for a few short years we live in the world as we find it; but soon, perhaps almost sooner than we know, we are making our own world, carving our own way, shaping our own thoughts, controlling our own destinies.

We are like travelers sent out on a journey, set in a path well marked and beaten down by the feet of friends who have gone before us. For a little way the path is clear and narrow, and friends protect and guide us as we go: we follow where they lead. But soon the way grows wide, and our friends are scattered; and the paths lead here and there, and cross and cross; and the signposts are so confusing, and in such strange languages, that we only half perceive their meaning; and we wander on and on, through unknown ways to unknown lands. No longer is the path marked out for us; we make it as we go, and we go whither we will.

Life is like that. We reach it through a narrow, guarded way, which leads into infinite space. We come into it with minds like a garden not yet planted—with soil half prepared, perhaps, so that it may have a tendency towards flowers instead of weeds, or towards weeds instead of flowers; but with the actual seeds unsown, so that we may make the garden almost what we will. For a little while the flowers come up about us and we have almost nothing to do with them; but soon the seeds are offered us by a thousand hands, bearing a thousand kinds of fruit, and we can take them or reject them as we will. What shall we take, and what shall we reject?

That is what will make our lives, building them up or pulling them down. The things we put into our pockets may be as nothing, though they be made of gold; but the things we put into our minds are all the world to us, though they fall from the skies, or rise from the valleys, or pour out upon us from the hills, and cost us nothing. *We are what we think.* We are as old as we feel, as rich or as poor as our imagination. We are as strong as our faith or as weak as our fears. It is these things that make up life for us: it is your mind that makes your world, and your mind is *what you make it.*

You have often heard people say, no doubt, that if they could make their own world they would be perfectly happy, and perhaps you have thought so too. Well, the boundaries of your kingdom are rising up around you, and you are forming them. Even now, while life is so pleasant and the years bring no burden for you to carry, you are laying for yourself the foundations of a world in which you will live, I hope, to a serene old age. Upon the thoughts you admit into your mind now, more than upon anything else, will rest the fortunes of your future years, and you can hand on to your future no more precious inheritance than a mind well filled, well balanced, and well controlled.

WE MUST BE BRAVE ENOUGH TO RESTRAIN OUR FEELINGS

It is not easy to restrain the natural feelings of pity that come to us when we see or hear sad things, and it will be a sad day for the world when sorrow

and pain cease to stir our feelings. But it would be worse for us all if, in our pity, we shut our eyes and hearts and minds to other feelings. We must be strong enough to bear the sight of pain for healing's sake, or where would doctors and nurses come from? We must be stern enough to punish wrong-doing, or what would become of peaceful people? It is right that we should regret the need of causing pain, but it is wrong that we should shun the painful duties that we owe to ourselves and to others. We must learn to look wisely upon all sides of life, and not give way to the feelings that belong to only one side of things.

WHY WE MUST GIVE OUR REASON FULL CONTROL OF OUR EMOTIONS

And so we see that we must give our reason full control of our emotions. We must think long, long thoughts, and not only for the moment and the hour. We must not let momentary feelings, so lightly roused, govern the acts of our lives. We must not let one emotion seize hold of us, and control us and dominate our lives until it possesses us completely. We must not let our love of dogs, for example, blind us to the fact that sometimes, at the cost of a little pain to one of these brave animals, we may save the lives of children. We must not let any emotion so utterly possess us that we are carried away by it.

Without this balance, this careful adjustment of the scales of reason and emotion, our lives must lose much of their happiness for ourselves and much of their usefulness to others.

THE MISTAKE THAT WE MUST GUARD AGAINST IN GIVING OUR SYMPATHIES

All through our lives we shall be forming our opinions, fixing our attitude to this or that great movement, resolving which side we will take in a hundred questions. From all sides the appeal to our sympathy will come and in the stress of life, in the midst of all its clashing interests, it will not be easy to decide. Often it will seem that two ways are right, when only one can be taken, and often the way that seems right will mean pain to those we love, or suffering to ourselves that we could avoid by pursuing another way. And sometimes it will seem as if to find the truth is quite impossible.

THE STILL SMALL VOICE WITHIN THAT WILL NEVER BETRAY US

When these things come we shall do what seems to us right; we shall listen to the still small voice within us which never yet has led any one of us astray. We shall remember, not merely the things that crowd upon our minds at the moment, but the way in which the acts of our lives are wrought into a chain that never ends, but links the human race from age to age. In all things we must consider the far-off end, the ultimate purpose of Life.

You will have your share of the fears and worries that come to us all, and you will bear them bravely. But you will be wise, and you will not suffer your feelings to mislead you. You will open your heart to sorrow, you will open your mind to knowledge, and you will live in a world of thought and feeling which not all the armies of this world could destroy.

PRACTICAL ARITHMETIC AND CALCULATIONS

THE FUNDAMENTAL PROCESSES

ADDITION

Addition is a short way of uniting two or more numbers into one number.

The numbers to be added are called *Addends.*

The result of adding is called the *Sum.*

The sign of addition (+) is the erect cross, which is read "plus" or "and."

The sign of equality is =, or two short horizontal lines placed one above the other. It is read "equals."

Only numbers of the same kind can be added. We can add 4 cows and 9 cows; the sum is 13 cows; but we cannot add 6 books and 4 slates, as the sum would be neither books nor slates.

A number of some particular kind, as 5 balls, 6 horses, is called a *Concrete Number.*

A number used without reference to any particular thing, as 8, is an *Abstract Number.*

Any two or more abstract numbers can be united into one sum because they do not refer to any particular objects.

ORAL EXERCISES

Count by 2's to 100; by 3's to 99; by 4's to 100; by 5's to 100; by 6's to 96; by 7's to 98; by 8's to 96; by 9's to 99.

Beginning with 1, count by 2's to 99.

Beginning with 1, count by 3's to 100; beginning with 1, count by 4's to 97; beginning with 1 count by 5's, by 6's, by 7's, by 8's and by 9's.

ADDITION DRILL

NOTE.—This table contains all of the primary combinations in addition. It should be learned for speed and reviewed frequently. Every child should learn to be speedy with this table.

	A	B	C	D	E	F	G	H	I	J
1.	1	1	2	1	3	3	4	4	3	1
	1	2	2	3	2	3	1	2	4	5
2.	5	4	1	5	4	2	7	2	1	8
	2	4	6	3	5	6	1	7	8	2
3.	3	5	9	7	4	2	4	5	6	7
	6	5	1	3	6	9	8	7	5	4
4.	5	8	6	9	7	3	8	7	8	9
	9	3	6	6	8	9	9	7	8	2
5.	5	9	8	6	6	8	7	9	9	8
	8	9	6	9	7	5	9	4	6	7

Use this table as a drill in every possible way, up and down and to the right and to the left. Use a watch to encourage speed.

Method or Rule for Addition.—In order to add numbers conveniently, write the numbers so that units shall be under units, tens under tens, hundreds under hundreds, and so on. Add each column separately, beginning at the right. If the sum of any column is greater than 9, set down only the right-hand figure of the sum and add the other figure to the next column to the left.

EXERCISES

Add—

1.	2.	3.	4.	5.	6.
7832	9132	7911	4668	7848	2314
7386	8617	5687	4578	8337	8430
7510	2731	1234	7433	8664	9999
1832	3056	7638	6340	7931	6327
1647	7690	1967	3257	5419	6327
9975	9537	4350	1861	3228	6730

NOTE.—The above problems should be used to attain speed and accuracy. Make this a game in which the pupils are contesting to win. Have them start at a given signal.

WRITTEN PROBLEMS

1. A cottage was planned to cost $1000. The foundation and brick work cost $428.80, lumber $370.15, carpentering $264.87, painting and plastering $253.25, hardware $38.90, tinwork $13.78. What did the house actually cost?

2. A farm which cost $6275 was equipped as follows: House $1588.77, teams, $850, a driving horse $175, cattle $275, hogs $127, implements and tools $677. What is the total value of the farm and its equipment?

3. A family of two persons spends for rent $130, food, $210, clothing $80, fuel $30, light $6, insurance $24, replenishing $10, carfare $5, literature $5, charity $10, and saves $20. What is the income?

4. Find the cost of raising an acre of corn if the rent is $3.03, fertilizer $1.86, plowing, etc., $1.62, planting $1.42, cultivating $1.80, harvesting $3, and other expenses $1.76.

Subtraction is the process of finding the difference between two numbers. The larger of the two numbers is called the *Minuend.* The number which is subtracted is called the *Subtrahend.*

The result of the subtraction is the *Difference* or *Remainder.*

SUBTRACTION DRILL

NOTE.—The teacher using a watch should place a limit of so many seconds, say thirty, and see who can go farthest with this table in this time. Use every device you can to encourage this rapid work and do it every day until the pupil is proficient.

Subtract—

8	6	7	8	7	5	6	7	9	8
5	2	3	6	2	2	4	4	7	3
6	7	8	9	6	9	8	9	9	9
3	5	4	2	2	4	2	3	5	6
10	11	10	12	11	10	12	10	11	12
7	3	8	5	4	6	6	5	7	9
13	11	13	12	13	14	11	12	11	12
4	5	7	8	9	9	6	7	9	4
14	15	16	11	15	13	14	12	13	11
8	9	8	8	6	6	7	3	5	2
13	15	14	16	16	14	15	18	17	17
8	7	6	9	7	5	8	9	9	8

MAKING CHANGE

In making change we add to the amount of the sale enough money to equal the amount given in payment.

EXAMPLE.—A customer buys goods amounting to $3.45 and gives a five-dollar bill in payment. Count out the change.

Amount of sale:	Change:
$3.45	$0.05
	.50
	1.00
	$1.55

$1.55 Amount of change.

$5.00 Amount given in payment.

Merchant says: "Three-forty-five, three-fifty, four dollars, five dollars."

The merchant desiring to use the least number of pieces of money would hand the customer his package, a nickel, a halfdollar, and a dollar, and say, "three-forty-five, three-fifty, four, five dollars."

The customer should always count his change as the merchant makes it.

ORAL PROBLEMS IN MAKING CHANGE

	Amount of Sale	Money Payment	Change
1.	$ 0.30	a half dollar	how much? what pieces?
2.	.65	one dollar	how much? what pieces?
3	1.02	a dollar and a quarter	how much? what pieces?
4.	1.35	two dollars	how much? what pieces?
5.	1.55	five-dollar bill	how much? what pieces?
6.	2.20	two two-dollar bills	how much? what pieces?
7.	3.65	a five-dollar bill	how much? what pieces?
8.	6.85	a ten-dollar bill	how much? what pieces?
9.	11.65	a twenty-dollar bill	how much? what pieces?

WRITTEN EXERCISES

1. From 896,192 subtract 425,327.

		5	11	8	12
8	9	6	1	9	2
4	2	5	3	2	7
4	7	0	8	6	5

You cannot take 7 units from 2 units. Take 1 ten from 9 tens; this with the 2 units makes 12 units. This leaves 5 units.

Eight tens remain in the Minuend. Taking 2 from 8 leaves 6.

In a similar manner, taking 3 from 11 leaves 8, taking 5 from 5 leaves 0, taking 2 from 9 leaves 7 and taking 4 from 8 leaves 4.

2. From 6,000,600 subtract 172,316.

	6	9	9	10	5	9	10
6	0	0	0	6	0	0
	1	7	2	3	1	6
5	8	2	8	2	8	4

When the Minuend contains zeros think of each zero as 9 except the right-hand one in each group which is thought of as 10. Note that 1 of the 6 hundreds in the Minuend makes the 9 tens and the 10 units. Also, 1 of the 5 millions makes the 9 hundreds, the 9 tens, and the 10 units of the thousands 8 period.

CHECKING SUBTRACTION

The accuracy of the work is checked by adding the Difference to the Subtrahend. The sum of these two numbers should be the same as the Minuend.

Subtract—

1.	2.	3.	4.	5.	6.
760	571	4705	21,504	34,576	78,765
369	296	2482	18,396	22,688	56,899

WRITTEN PROBLEMS

1. From London to Bombay by the Cape of Good Hope is 11,220 miles; by way of the Suez Canal it is 6332 miles. How many miles does the Suez Canal save in going by water from London to Bombay?

2. The distance from New York to San Francisco by way of Cape Horn is 13,135 miles; by way of Panama it is 5262 miles. Find the distance saved by the Panama Canal.

3. From New York to Melbourne by way of Cape Horn is 12,852 miles; by way of Panama Canal it is 10,392 miles. How much does the Panama Canal save between New York and Melbourne?

MULTIPLICATION

Multiplication is a short way of adding a set of equal numbers. Thus: $4 \times 3 = 12$, is the short way of writing 3 plus 3 plus 3 plus 3 equals 12; and $7 \times 4 = 28$, is the short way of writing 4 plus 4 plus 4 plus 4 plus 4 plus 4 plus 4 equals 28.

The number to be multiplied is called the *Multiplicand;* the number by which we multiply is called the *Multiplier;* and the result of the process is called the *Product.* The Multiplier and Multiplicand are also sometimes called the Factors of the Product.

THE MULTIPLICATION TABLE

NOTE.—It is absolutely necessary for every pupil to know this table thoroughly in order to make any progress at all in Arithmetic. Use the watch in timing each pupil. A pupil should be able to give any one table forward and backward in from thirty to forty seconds. No child who cannot do this should be allowed to think that he has mastered this table:

CHART I

Have children count by 1's; 2's; 4's and 3's.

Teach that multiplication is a short method of adding.

♦ Signifies new numbers found in other tables of Charts I and II.

\+ Signifies old numbers having been studied in other tables of Charts I and II.

Let the children discover in the new table how many numbers they have studied in other tables.

	1 × 1 =			1
♦	2 × 1 =			2
♦	3 × 1 =			3
♦	4 × 1 =			4
♦	5 × 1 =			5
	6 × 1 =			6
	7 × 1 =			7
	8 × 1 =			8
♦	9 × 1 =			9
♦	10 × 1 =		1	0
♦	11 × 1 =		1	1
	12 × 1 =		1	2

+	1 × 2 =			2
	2 × 2 =			4
♦	3 × 2 =			6
♦	4 × 2 =			8
♦	5 × 2 =		1	0
	6 × 2 =		1	2
	7 × 2 =		1	4
	8 × 2 =		1	6
♦	9 × 2 =		1	8
♦	10 × 2 =		2	0
♦	11 × 2 =		2	2
	12 × 2 =		2	4

+	1 × 4 =			4
+	2 × 4 =			8
	3 × 4 =		1	2
	4 × 4 =		1	6
♦	5 × 4 =		2	0
	6 × 4 =		2	4
	7 × 4 =		2	8
	8 × 4 =		3	2
♦	9 × 4 =		3	6
♦	10 × 4 =		4	0
♦	11 × 4 =		4	4
	12 × 4 =		4	8

+	1 × 3 =			3
+	2 × 3 =			6
	3 × 3 =			9
+	4 × 3 =		1	2
♦	5 × 3 =		1	5
	6 × 3 =		1	8
	7 × 3 =		2	1
	8 × 3 =		2	4
♦	9 × 3 =		2	7
♦	10 × 3 =		3	0
♦	11 × 3 =		3	3
	12 × 3 =		3	6

CHART A

Drill the 1's, 2's, 4's, and 3's separately as a closing review for each of the tables studied.

Develop the fact of the reversibility of numbers as $1 \times 2 =$, $2 \times 1 =$, etc., except the square of numbers as $1 \times 1 =$, $2 \times 2 =$, etc. Develop or omit drills as circumstances require.

Study the 5's and 6's with Chart II.

The numbers in black on this chart and on Chart C indicate the numbers in the 6's; 7's, 8's and 12's not studied in the other eight tables.

These numbers are tabulated for study on Chart II. If the numbers are properly reviewed in couplets, the children will show an intelligent appreciation of the fact that they have only ten combinations to study in these four tables.

1 × 1 =	2 × 1 =	3 × 1 =	4 × 1 =	5 × 1 =	6 × 1 =
1 × 2 =	1 × 2 =	1 × 3 =	1 × 4 =	1 × 5 =	1 × 6 =
2 × 1 =	2 × 2 =	3 × 2 =	4 × 2 =	5 × 2 =	6 × 2 =
1 × 3 =	2 × 3 =	2 × 3 =	2 × 4 =	2 × 5 =	2 × 6 =
3 × 1 =	3 × 2 =	3 × 3 =	4 × 3 =	5 × 3 =	6 × 3 =
1 × 4 =	2 × 4 =	3 × 4 =	3 × 4 =	3 × 5 =	3 × 6 =
4 × 1 =	4 × 2 =	4 × 3 =	4 × 4 =	5 × 4 =	6 × 4 =
1 × 5 =	2 × 5 =	3 × 5 =	4 × 5 =	4 × 5 =	4 × 6 =
5 × 1 =	5 × 2 =	5 × 3 =	5 × 4 =	5 × 5 =	6 × 5 =
1 × 6 =	2 × 6 =	3 × 6 =	4 × 6 =	5 × 6 =	5 × 6 =
6 × 1 =	6 × 2 =	6 × 3 =	6 × 4 =	6 × 5 =	**6 × 6 =**
1 × 7 =	2 × 7 =	3 × 7 =	4 × 7 =	5 × 7 =	**6 × 7 =**
7 × 1 =	7 × 2 =	7 × 3 =	7 × 4 =	7 × 5 =	7 × 6 =
1 × 8 =	2 × 8 =	3 × 8 =	4 × 8 =	5 × 8 =	**6 × 8 =**
8 × 1 =	8 × 2 =	8 × 3 =	8 × 4 =	8 × 5 =	8 × 6 =
1 × 9 =	2 × 9 =	3 × 9 =	4 × 9 =	5 × 9 =	6 × 9 =
9 × 1 =	9 × 2 =	9 × 3 =	9 × 4 =	9 × 5 =	9 × 6 =
1 × 10 =	2 × 10 =	3 × 10 =	4 × 10 =	5 × 10 =	6 × 10 =
10 × 1 =	10 × 2 =	10 × 3 =	10 × 4 =	10 × 5 =	10 × 6 =
1 × 11 =	2 × 11 =	3 × 11 =	4 × 11 =	5 × 11 =	6 × 11 =
11 × 1 =	11 × 2 =	11 × 3 =	11 × 4 =	11 × 5 =	11 × 6 =
1 × 12 =	2 × 12 =	3 × 12 =	4 × 12 =	5 × 12 =	**6 × 12 =**
12 × 1 =	12 × 2 =	12 × 3 =	12 × 4 =	12 × 5 =	12 × 6 =

CHART B

DRILLS FOR BLACKBOARD OR PAPER

Suggestions for blackboard or speed drills to be used at the discretion of the teacher. This may be developed throughout all the tables. The children should know each combination independently and instantaneously.

× 1		÷ 1	
5			11
3			4
8			7
11			10
4			1
12			6
7			9
1			2
9			5
6			8
2			12
10			3

× 2		÷ 2	
7			22
12			10
3			18
5			4
9			12
1			20
8			8
6			24
10			16
4			2
11			6
2			14

× 4		÷ 4	
12			40
9			8
1			12
6			32
10			20
7			4
3			44
11			36
8			28
2			16
5			24
4			48

× 3		÷ 3	
9			24
1			3
6			9
10			18
8			30
5			12
11			6
7			36
2			15
12			27
4			21
3			33

CHART II

Thoroughly develop the idea of units, tens and hundreds columns. Again master each table separately and review as suggested by drill charts before beginning a new table.

1st. Suggest that the 10 is made of a cipher in its units number and a 1 in its tens number. Also that the units number in the answer is a cipher; and that the 10's or 10's and 100's numbers are the same as the numbers we multiply by 10.

Teach that multiplying by 10 is the same as multiplying by 1 and adding an 0 to the units column.

This idea may be developed into rapid drills of multiplying by 10's; 100's; 1000's: etc., by adding 0's.

The 2's, 4's, and 3's can be reviewed by multiplying by 20, 40, and 30; or by 200, 400, and 300, etc., by adding 0's.

2nd. Note that the 11 is composed of 2 ones; and that in the answer, both the units and tens columns contain the same numbers, as 11, 22, etc. The black line separates numbers not belonging to the rule $(10 \times 11) = (11 \times 10)$;, ∴ only two combinations remain to be studied.

+	1 × 10 =		1	0
+	2 × 10 =		2	0
+	3 × 10 =		3	0
+	4 × 10 =		4	0
◆	5 × 10 =		5	0
	6 × 10 =		6	0
	7 × 10 =		7	0
	8 × 10 =		8	0
◆	9 × 10 =		9	0
	10 × 10 =	1	0	0
◆	11 × 10 =	1	1	0
	12 × 10 =	1	2	0

+	1 × 11 =		1	1
+	2 × 11 =		2	2
+	3 × 11 =		3	3
+	4 × 11 =		4	4
◆	5 × 11 =		5	5
	6 × 11 =		6	6
	7 × 11 =		7	7
	8 × 11 =		8	8
◆	9 × 11 =		9	9
+	10 × 11 =	1	1	0
	11 × 11 =	1	2	1
	12 × 11 =	1	3	2

+	2 × 5 =		1	0
+	4 × 5 =		2	0
	6 × 5 =		3	0
	8 × 5 =		4	0
+	10 × 5 =		5	0
	12 × 5 =		6	0
+	1 × 5 =			5
+	3 × 5 =		1	5
	5 × 5 =		2	5
	7 × 5 =		3	5
◆	9 × 5 =		4	5
+	11 × 5 =		5	5

+	1 × 9 =			9
+	2 × 9 =		1	8
+	3 × 9 =		2	7
+	4 × 9 =		3	6
+	5 × 9 =		4	5
	6 × 9 =		5	4
	7 × 9 =		6	3
	8 × 9 =		7	2
	9 × 9 =		8	1
+	10 × 9 =		9	0
+	11 × 9 =		9	9
	12 × 9 =	1	0	8

	6 × 6 =		3	6
	7 × 6 =		4	2
	8 × 6 =		4	8
	12 × 6 =		7	2
	7 × 7 =		4	9

	8 × 7 =		5	6
	12 × 7 =		8	4
	8 × 8 =		6	4
	12 × 8 =		9	6
	12 × 12 =	1	4	4

Keep the facts observed in mind during drills.

3d. First multiply 5 by even numbers, then by odd numbers. Note that 5 is one-half of 10 and that the answers are just one-half as much as if multiplied by 10.

Note that even numbers multiplied by 5 have 0 in their unit column; but (2 × 5) = only one-half (2 × 10), etc. Odd numbers multiplied by 5 have 5 in their units column. Drill on (3 × 5) = (3 × 10 + 5); (5 × 5) = (2 × 10 + 5); etc.

4th. Let the children suggest the simple points they see in the 9's. Have them observe 9 is one less than 10; and their answer in the 10's column is one less than the number they have multiplied by 9.

The sum of the ten's and units columns is 9. The black line denotes the exceptions. (11 × 9) = (9 × 11); ∴ there is only one combination to study. Drill and review.

5th. For the 10 numbers of the 6's, 7's, 8's and 12's tables, follow previous directions.

7 × 1 =	8 × 1 =	9 × 1 =	10 × 1 =	11 × 1 =	12 × 1 =
1 × 7 =	1 × 8 =	1 × 9 =	1 × 10 =	1 × 11 =	1 × 12 =
7 × 2 =	8 × 2 =	9 × 2 =	10 × 2 =	11 × 2 =	12 × 2 =
2 × 7 =	2 × 8 =	2 × 9 =	2 × 10 =	2 × 11 =	2 × 12 =
7 × 3 =	8 × 3 =	9 × 3 =	10 × 3 =	11 × 3 =	12 × 3 =
3 × 7 =	3 × 8 =	3 × 9 =	3 × 10 =	3 × 11 =	3 × 12 =
7 × 4 =	8 × 4 =	9 × 4 =	10 × 4 =	11 × 4 =	12 × 4 =
4 × 7 =	4 × 8 =	4 × 9 =	4 × 10 =	4 × 11 =	4 × 12 =
7 × 5 =	8 × 5 =	9 × 5 =	10 × 5 =	11 × 5 =	12 × 5 =
5 × 7 =	5 × 8 =	5 × 9 =	5 × 10 =	5 × 11 =	5 × 12 =
7 × 6 =	8 × 6 =	9 × 6 =	10 × 6 =	11 × 6 =	12 × 6 =
6 × 7 =	6 × 8 =	6 × 9 =	6 × 10 =	6 × 11 =	6 × 12 =
7 × 7 =	8 × 7 =	9 × 7 =	10 × 7 =	11 × 7 =	12 × 7 =
7 × 8 =	7 × 8 =	7 × 9 =	7 × 10 =	7 × 11 =	7 × 12 =
8 × 7 =	8 × 8 =	9 × 8 =	10 × 8 =	11 × 8 =	12 × 8 =
7 × 9 =	8 × 9 =	8 × 9 =	8 × 10 =	8 × 11 =	8 × 12 =
9 × 7 =	9 × 8 =	9 × 9 =	10 × 9 =	11 × 9 =	12 × 9 =
7 × 10 =	8 × 10 =	9 × 10 =	9 × 10 =	9 × 11 =	9 × 12 =
10 × 7 =	10 × 8 =	10 × 9 =	10 × 10 =	11 × 10 =	12 × 10 =
7 × 11 =	8 × 11 =	9 × 11 =	10 × 11 =	10 × 11 =	10 × 12 =
11 × 7 =	11 × 8 =	11 × 9 =	11 × 10 =	11 × 11 =	12 × 11 =
7 × 12 =	8 × 12 =	9 × 12 =	10 × 12 =	11 × 12 =	11 × 12 =
12 × 7 =	12 × 8 =	12 × 9 =	12 × 10 =	12 × 11 =	12 × 12 =

CHART C

Follow previous directions. This chart may also be combined with Chart A; and studied across the pages instead of down the columns.

Blackboard drills as suggested by Chart B may be continued effectively.

CHART III

This review chart is so arranged, that all the answers are in order according to size from 1 to 144. Also all combinations having the same answers are classed together. It is useful for busy work, or rapid drills.

1 × 1 =	1 × 12 =	4 × 6 =	11 × 4 =	6 × 12 =
1 × 2 =	12 × 1 =	6 × 4 =	5 × 9 =	12 × 6 =
2 × 1 =	2 × 6 =	5 × 5 =	9 × 5 =	7 × 11 =
1 × 3 =	6 × 2 =	3 × 9 =	4 × 12 =	11 × 7 =
3 × 1 =	3 × 4 =	9 × 3 =	12 × 4 =	8 × 10 =
1 × 4 =	4 × 3 =	4 × 7 =	6 × 8 =	10 × 8 =
4 × 1 =	2 × 7 =	7 × 4 =	8 × 6 =	9 × 9 =
2 × 2 =	7 × 2 =	3 × 10 =	7 × 7 =	7 × 12 =
1 × 5 =	3 × 5 =	10 × 3 =	5 × 10 =	12 × 7 =
5 × 1 =	5 × 3 =	5 × 6 =	10 × 5 =	8 × 11 =
1 × 6 =	2 × 8 =	6 × 5 =	6 × 9 =	11 × 8 =
6 × 1 =	8 × 2 =	4 × 8 =	9 × 6 =	9 × 10 =
2 × 3 =	4 × 4 =	8 × 4 =	5 × 11 =	10 × 9 =
3 × 2 =	2 × 9 =	3 × 11 =	11 × 5 =	8 × 12 =
1 × 7 =	9 × 2 =	11 × 3 =	7 × 8 =	12 × 8 =
7 × 1 =	3 × 6 =	5 × 7 =	8 × 7 =	9 × 11 =
1 × 8 =	6 × 3 =	7 × 5 =	6 × 10 =	11 × 9 =
8 × 1 =	2 × 10 =	3 × 12 =	10 × 6 =	10 × 10 =
2 × 4 =	10 × 2 =	12 × 3 =	5 × 12 =	9 × 12 =
4 × 2 =	4 × 5 =	4 × 9 =	12 × 5 =	12 × 9 =
1 × 9 =	5 × 4 =	9 × 4 =	7 × 9 =	10 × 11 =
9 × 1 =	3 × 7 =	6 × 6 =	9 × 7 =	11 × 10 =
3 × 3 =	7 × 3 =	4 × 10 =	8 × 8 =	10 × 12 =
1 × 10 =	2 × 11 =	10 × 4 =	6 × 11 =	12 × 10 =
10 × 1 =	11 × 2 =	5 × 8 =	11 × 6 =	11 × 11 =
2 × 5 =	2 × 12 =	8 × 5 =	7 × 10 =	11 × 12 =
5 × 2 =	12 × 2 =	6 × 7 =	10 × 7 =	12 × 11 =
1 × 11 =	3 × 8 =	7 × 6 =	8 × 9 =	12 × 12 =
11 × 1 =	8 × 3 =	4 × 11 =	9 × 8 =	

CHART IV

The six tables containing the most difficult numbers are arranged vertically instead of horizontally, so that the child may become accustomed to the difference in the position of numbers.

	3 ×1	1 3	3 2	2 3	3 3	3 4	4 3	3 5	5 3	3 6	6 3
3 7	7 3	3 8	8 3	3 9	9 3	3 10	10 3	3 11	11 3	3 12	12 3
	4 1	1 4	4 2	2 4	4 3	3 4	4 4	4 5	5 4	4 6	6 4
4 7	7 4	4 8	8 4	4 9	9 4	4 10	10 4	4 11	11 4	4 12	12 4
	6 1	1 6	6 2	2 6	6 3	3 6	6 4	4 6	6 5	5 6	6 6
6 7	7 6	6 8	8 6	6 9	9 6	6 10	10 6	6 11	11 6	6 12	12 6
	7 1	1 7	7 2	2 7	7 3	3 7	7 4	4 7	7 5	5 7	7 6
6 7	7 7	7 8	8 7	7 9	9 7	7 10	10 7	7 11	11 7	7 12	12 7
	8 1	1 8	8 2	2 8	8 3	3 8	8 4	4 8	8 5	5 8	8 6
6 8	8 7	7 8	8 8	8 9	9 8	8 10	10 8	8 11	11 8	8 12	12 8
	12 1	1 12	12 2	2 12	12 3	3 12	12 4	4 12	12 5	5 12	12 6
6 12	12 7	7 12	12 8	8 12	12 9	9 12	12 10	10 12	12 11	11 12	12 12

CHART D

1

It is suggested that as the children study the tables and review, they should be required to count by the number by which they have learned to multiply, and that in final review, they should be able to write them as suggested here, and cross out all the numbers that occur more than once.

2

This could be used for busy work drills; or, the teacher could select products, and require the children to give all the combinations that make them. It is also interesting to add some number to the product, as 37 instead of 36. The children will then give

$$(6 \times 6 + 1);\ \left.\begin{matrix} 4 \times 9 \\ 9 \times 4 \end{matrix}\right\} + 1;\ \left.\begin{matrix} 12 \times 3 \\ 3 \times 12 \end{matrix}\right\} + 1.$$

1

1	~~2~~	~~3~~	~~4~~	~~5~~	~~6~~	~~7~~	~~8~~	~~9~~	~~10~~	~~11~~	~~12~~
2	~~4~~	~~6~~	~~8~~	~~10~~	~~12~~	~~14~~	~~16~~	~~18~~	~~20~~	~~22~~	~~24~~
3	~~6~~	~~9~~	~~12~~	~~15~~	~~18~~	~~21~~	~~24~~	~~27~~	~~30~~	~~33~~	~~36~~
4	~~8~~	~~12~~	~~16~~	~~20~~	~~24~~	~~28~~	~~32~~	~~36~~	~~40~~	~~44~~	~~48~~
5	~~10~~	15	~~20~~	25	~~30~~	~~35~~	~~40~~	~~45~~	~~50~~	~~55~~	~~60~~
6	~~12~~	~~18~~	~~24~~	~~30~~	~~36~~	~~42~~	~~48~~	~~54~~	~~60~~	~~66~~	~~72~~
7	14	21	28	35	42	49	~~56~~	~~63~~	~~70~~	~~77~~	~~84~~
8	16	24	32	~~40~~	~~48~~	56	64	~~72~~	~~80~~	~~88~~	~~96~~
9	18	27	~~36~~	45	54	63	~~72~~	81	~~90~~	~~99~~	~~108~~
10	20	30	40	50	~~60~~	70	80	90	100	~~110~~	~~120~~
11	22	33	44	55	66	77	88	99	110	121	~~132~~
12	24	36	48	60	72	84	96	108	120	132	144

2

1's	10's	20's	30's	40's	50's	60's	70's	80's	90's	100's
1	10	20	30	40	50	60	70	80	90	100
2	11	21	32	42	54	63	72	81	96	108
3	12	22	33	44	55	64	77	84	99	110
4	14	24	35	45	56	66		88		120
5	15	25	36	48						121
6	16	27		49						132
7	18	28								144
8										
9										

METHOD OF MULTIPLICATION

1. Multiply 46 by 10.

Adding a zero to the right of 46 changes the 6 to 60 and the 40 to 400; hence it multiplies the number by 10.

2. Multiply 426 by 300.

Long Method:	Short Method:
426	426
300	300
000	127800
000	
1278	
127800	

3. How many 0's would you annex to the right of your product if your multiplier were 20? 200? 80? 1000? 40,000?

Tell the products of the following at sight.

4.	10×800	9.	20×32
5.	10×775	10.	70×50
6.	10×185	11.	100×20
7.	10×128	12.	400×50
8.	10×381	13.	1000× 7

14. Multiply 8207 by 345.

15. Multiply 8217 by 305.

Multiplicand	8207
Multiplier	345
First Partial Product	41035
Second Partial Product	32828
Third Partial Product	14621
Entire Product	2832415

15. Multiply 8217 by 305.

Multiplicand	8217
Multiplier	305
First Partial Product	41085
Second Partial Product	24651
Entire Product	2506185

PROBLEMS

1. A grocer has two grades of butter, one of which sells for 40 cents a pound and the other for 32 cents a pound. How much will a family save in a year (52 weeks) by using the cheaper grade if they use three pounds a week?

2. When round steak is 22 cents a pound, and sirloin is 27 cents a pound, how much will a family that uses 64 pounds a month save by using round steak?

3. Suppose you could buy two kinds of flour, one at 75 cents a sack and the other at 88 cents a sack, and you use 18 sacks a year, how much more does the expensive flour cost you a year?

DIVISION

ORAL EXERCISES

1. Count by 6's from 36 to 0. How many 6's in 36. Count by 9's from 36 to 0.

From the above you will see that there are four 9's in 36, also that there are nine 4's in 36. Thus if we take 9 as a factor 4 times we have the product 36. In division we have given the product and one of the two factors to find the other factor.

Dividing the product by either factor gives the other factor: Thus: $36 \div 9 = 4$; $36 \div 4 = 9$.

In this case 36 is called the *Dividend;* while the factor used to divide by we call the *Divisor.* The result obtained by dividing which is the other factor, we call the *Quotient.*

SHORT DIVISION

When the divisor is not greater than 12 a process called *Short Division* is usually used.

1. Divide 852 by 3.

Solution:

3)852

284

EXPLANATION.—3 is contained in 8 (hundreds) 2 (hundred) times with a remainder of 2.

Write 2 in the hundreds place of the quotient. The remainder, 2 hundreds plus 5 tens, equals 25 tens.

25 tens divided by 3 equals 8 tens, with a remainder of 1.

Write 8 tens in the quotient in tens place. The 1 ten remainder plus 2 units equals 12 units.

12 units divided by 3 equals 4 units.

2.	856÷4	8.	1078÷7
3.	1624÷6	9.	792÷6
4.	1272÷6	10.	9136÷4
5.	1054÷9	11.	7468÷7
6.	1728÷8	12.	11,656÷9
7.	772 ÷5	13.	16,860÷6

WRITTEN PROBLEMS

160 Y 58006/6000

1. 600)96000 2. 6000)348096
3. Divide 480 by 10; by 20; by 30.4.
4. Divide 7200 by 40; by 400; by 900.
5. Divide 9600 by 60; by 600; by 800.
6. Divide 112000 by 700; by 800; by 7000.
7. Divide 108000 by 900; by 1200; by 9000.

NOTE.—A problem in division is checked or proved by multiplying the divisor by the quotient and adding the remainder, if there be one, to the product; the result should be the dividend.

LONG DIVISION

1. Divide 8745 by 37.

$236\frac{13}{37}$

Divisor: 37)8745 Dividend

74

134

111

235

222

13

EXPLANATION.—37 is contained in 87 (hundreds) 2 (hundreds) times with 13 (hundreds,

as remainder. The figure 2 is set down in the hundreds place of the quotient.

13 hundreds plus four tens equals 134 tens. 37 is contained in 134 (tens) 3 (tens) times, with a remainder of 23 tens. Place 3 in the quotient in tens place. 23 tens plus 5 units equals 235 units. 37 is contained in 235 units 6 times with a remainder of 13 units.

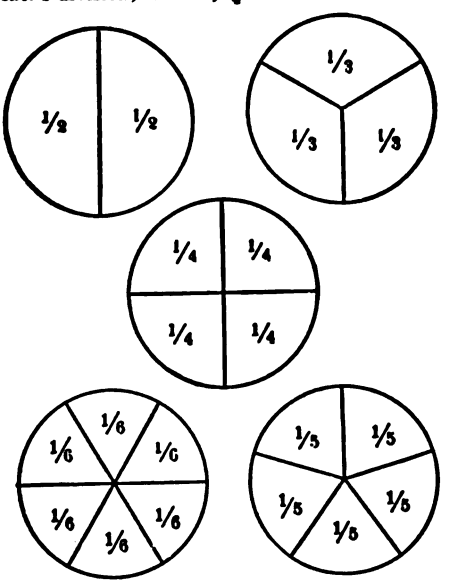
2. Divide 42832 by 184.
3. Divide 48210 by 85.
4. Divide 27152 by 67.
5. Divide 377289 by 927.

FRACTIONS

A *Fraction* is one or more of the equal parts into which a unit is divided: as one-third, three-fourths.

A Fraction is expressed by one figure written over another figure with a line between: $\frac{1}{2}$, $\frac{3}{4}$.

A Fraction may also be regarded as an indicated division; that is, $\frac{3}{4}$ is the same as $3 \div 4$.



The *Denominator* of a Fraction is the number below the line. It shows into how many equal parts the given unit is divided. Thus in $\frac{3}{4}$ the Denominator is 4.

The *Numerator* of a Fraction is the number which shows how many equal parts are taken. It is written above the line; thus in $\frac{3}{4}$ the Numerator is 3.

The Numerator and Denominator of a Fraction are called its *terms*.

A Fraction whose Numerator is less than its Denominator is called a *Proper Fraction;* as $\frac{5}{6}$, $\frac{9}{10}$.

A Fraction whose Numerator is equal to or greater than its Denominator is an *Improper Fraction:* as $\frac{4}{3}$; $\frac{9}{9}$.

A number composed of a Whole Number and a Fraction is called a *Mixed Number;* as $4\frac{3}{5}$. It is read "four and three-fifths."

REDUCTION OF FRACTIONS

The process of changing the form of a Fraction without changing its value is called *Reduction:* $\frac{1}{2} = \frac{2}{4} = \frac{6}{12}$.

1/2				1/2			
1/4		1/4		1/4		1/4	
1/12	1/12	1/12	1/12	1/12	1/12	1/12	1/12	1/12	1/12	1/12	1/12
1/3			1/3			1/3	
1/6		1/6		1/6		1/6	

A Fraction is reduced to lower terms when its terms are made smaller numbers; that is, $\frac{6}{12}$ is reduced to $\frac{1}{2}$, which are its lowest terms.

Multiplying or dividing both terms of a fraction by the same number does not change its value.

$\frac{3}{4} \times \frac{4}{4} = \frac{12}{16}$. $\frac{12}{16} \div \frac{4}{4} = \frac{3}{4}$.

Supply the missing Term:

1. $1 = \frac{\quad}{4}$; $1 = \frac{\quad}{8}$; $1 = \frac{\quad}{12}$; $\frac{1}{2} = \frac{\quad}{8}$; $\frac{1}{2} = \frac{\quad}{12}$.
2. $\frac{1}{3} = \frac{\quad}{6}$; $\frac{1}{3} = \frac{\quad}{12}$; $\frac{2}{3} = \frac{\quad}{6}$; $\frac{2}{3} = \frac{\quad}{12}$; $\frac{2}{3} = \frac{\quad}{18}$.
3. $\frac{1}{6} = \frac{\quad}{12}$; $\frac{1}{6} = \frac{\quad}{18}$; $\frac{5}{6} = \frac{\quad}{12}$; $\frac{2}{3} = \frac{\quad}{6}$; $\frac{4}{6} = \frac{\quad}{9}$.
4. $\frac{2}{12} = \frac{\quad}{6}$; $\frac{4}{12} = \frac{\quad}{9}$; $\frac{4}{12} = \frac{\quad}{6}$; $\frac{8}{12} = \frac{\quad}{9}$.

Solve without pencil, filling in blank numerator.

1. $\frac{1}{2} = \frac{\quad}{4}$; $\frac{1}{2} = \frac{\quad}{12}$; $\frac{3}{4} = \frac{\quad}{12}$; $\frac{3}{4} = \frac{\quad}{24}$; $\frac{3}{4} = \frac{\quad}{36}$.
2. $\frac{1}{3} = \frac{\quad}{6}$; $\frac{1}{3} = \frac{\quad}{12}$; $\frac{2}{3} = \frac{\quad}{12}$; $\frac{1}{6} = \frac{\quad}{24}$; $\frac{5}{6} = \frac{\quad}{24}$.
3. $\frac{1}{6} = \frac{\quad}{18}$; $\frac{1}{5} = \frac{\quad}{15}$; $\frac{2}{5} = \frac{\quad}{15}$; $\frac{2}{5} = \frac{\quad}{25}$; $\frac{2}{5} = \frac{\quad}{50}$.
4. $\frac{1}{8} = \frac{\quad}{24}$; $\frac{5}{8} = \frac{\quad}{24}$; $\frac{5}{8} = \frac{\quad}{80}$; $\frac{7}{8} = \frac{\quad}{48}$; $\frac{5}{8} = \frac{\quad}{48}$.
5. $\frac{5}{12} = \frac{\quad}{120}$; $\frac{7}{12} = \frac{\quad}{24}$; $\frac{5}{12} = \frac{\quad}{36}$; $\frac{11}{12} = \frac{\quad}{120}$; $\frac{11}{12} = \frac{\quad}{144}$.

REDUCE TO LOWEST TERMS.—A Fraction is in its lowest terms when both its terms contain no common divisor. Thus $\frac{2}{3}$ is in its lowest terms since 2 and 3 have no common divisor.

A fraction is reduced to lower terms by dividing both of its terms by the same number; thus $\frac{10}{15}$ is reduced to $\frac{2}{3}$ by dividing both terms by 5.

$$\frac{10 \div 5 = 2}{15 \div 5 = 3}$$

Reduce to lowest terms without a pencil:

	a	b	c	d	e	f	g
1.	$\frac{4}{8}$	$\frac{6}{10}$	$\frac{8}{12}$	$\frac{12}{24}$	$\frac{16}{20}$	$\frac{18}{30}$	$\frac{12}{24}$
2.	$\frac{10}{18}$	$\frac{12}{32}$	$\frac{15}{20}$	$\frac{10}{32}$	$\frac{14}{35}$	$\frac{18}{27}$	$\frac{12}{32}$
3.	$\frac{6}{12}$	$\frac{8}{16}$	$\frac{11}{44}$	$\frac{12}{44}$	$\frac{16}{32}$	$\frac{11}{33}$	$\frac{24}{32}$
4.	$\frac{12}{30}$	$\frac{18}{30}$	$\frac{11}{33}$	$\frac{12}{44}$	$\frac{22}{44}$	$\frac{24}{30}$	$\frac{22}{44}$
5.	$\frac{18}{20}$	$\frac{35}{70}$	$\frac{35}{50}$	$\frac{12}{30}$	$\frac{35}{50}$	$\frac{55}{100}$	$\frac{80}{100}$

Reduce to lowest terms with pencil:

1. $\frac{12}{30}$

SOLUTION. $\frac{12}{30} = \frac{12}{10} = \frac{4}{10} = \frac{2}{5}$ Ans.

2. $\frac{20}{105}$; $\frac{26}{176}$; $\frac{128}{168}$; $\frac{124}{144}$; $\frac{198}{528}$.
3. $\frac{128}{168}$; $\frac{216}{480}$; $\frac{750}{750}$; $\frac{450}{600}$; $\frac{1750}{1000}$.
4. $\frac{225}{300}$; $\frac{750}{1250}$; $\frac{750}{1000}$; $\frac{250}{750}$; $\frac{450}{1000}$.

REDUCING WHOLE OR MIXED NUMBERS TO IMPROPER FRACTIONS.—Reduce $2\frac{1}{3}$ to thirds.
Solution: $2\times\frac{3}{3}=\frac{6}{3}+\frac{1}{3}=\frac{7}{3}$

RULE.—Multiply the whole number by the denominator and add the numerator for a numerator. Under it write the given denominator.

Solve without pencil:

1. $5\frac{3}{4}=\frac{?}{4}$; $3\frac{1}{3}=\frac{?}{3}$; $5\frac{2}{3}=\frac{?}{3}$; $6\frac{2}{3}=\frac{?}{3}$.
2. $4=\frac{?}{7}$; $5\frac{3}{5}=\frac{?}{5}$; $5\frac{5}{6}=\frac{?}{6}$; $4\frac{1}{3}=\frac{?}{3}$.
3. $6=\frac{?}{3}$; $6\frac{1}{3}=\frac{?}{3}$; $6\frac{2}{3}=\frac{?}{3}$; $8\frac{1}{7}=\frac{?}{7}$.

Solve with pencil:

4. Reduce $33\frac{2}{3}$ to thirds.

SOLUTION. $33\times3=\frac{101}{3}$ Ans.

5. $62\frac{1}{4}$; $133\frac{1}{3}$; $166\frac{2}{3}$; $137\frac{1}{2}$; $187\frac{1}{2}$.
6. $270\frac{3}{8}$ feet; $310\frac{5}{8}$; $\$73\frac{1}{10}$; $16\frac{5}{12}$ years; $111\frac{1}{18}$ acres.

Reducing an Improper Fraction to a whole or mixed number; show by making and dividing circles that $\frac{6}{3}=2\frac{1}{3}$; $\frac{7}{3}=2\frac{1}{3}$; $\frac{9}{4}=2\frac{1}{4}$.

Solve without pencil, reducing to whole or mixed numbers:

1. $\frac{7}{2}$; $\frac{7}{3}$; $\frac{8}{3}$; $\frac{11}{3}$; $\frac{13}{4}$; $\frac{15}{4}$; $\frac{21}{6}$.
2. $\frac{15}{3}$; $\frac{15}{4}$; $\frac{25}{4}$; $\frac{15}{6}$; $\frac{19}{6}$; $\frac{27}{6}$; $\frac{29}{6}$.

Reduce to whole or mixed numbers with pencil:

3. Reduce $\frac{545}{17}$ to a whole or mixed number:

SOLUTION. $545 \quad 32\frac{1}{17}$

17)545
51
35
34
1

4. $\frac{55}{12}$ $\frac{254}{8}$ $\frac{501}{6}$ $\frac{132}{11}$ $\frac{678}{12}$ $\frac{100}{12}$ $\frac{200}{15}$ $\frac{1000}{6}$
5. $7\frac{2}{3}$ feet; $\frac{52}{6}$ mi.; $\$\frac{292}{10}$; $\frac{124}{5}$ days; $\frac{152}{7}$ weeks; $\$\frac{756}{11}$; $\$\frac{877}{15}$; $\$\frac{508}{35}$.

REDUCING FRACTIONS TO THE LEAST COMMON DENOMINATOR.—Those Fractions which have the same denominator are called *Similar Fractions*. The Fractions, $\frac{1}{6}$, $\frac{3}{6}$ and $\frac{5}{6}$, are Similar Fractions. In order to add or subtract Fractions conveniently, we must reduce them to similar fractions.

1. Reduce $\frac{1}{3}$, $\frac{7}{8}$, $\frac{5}{12}$ to similar fractions.

SOLUTION:

3)3, 8, 12 $\quad \frac{1}{3}=\frac{?}{24}$; $\frac{1}{3}=\frac{8}{24}$.

4)1 8 4 $\quad \frac{7}{8}=\frac{?}{24}$; $\frac{7}{8}=\frac{21}{24}$.

1 2 1 $\quad \frac{5}{12}=\frac{?}{24}$; $\frac{5}{12}=\frac{10}{24}$

$3\times4\times2=24$, the Common Denominator.

2. Reduce $\frac{2}{5}$, $\frac{5}{7}$, $\frac{7}{35}$ to Similar Fractions.

SOLUTION:

5)5, 7, 35 $\quad \frac{2}{5}=\frac{?}{35}$; $\frac{2}{5}=\frac{14}{35}$.

7)1, 7, 7 $\quad \frac{5}{7}=\frac{?}{35}$; $\frac{5}{7}=\frac{25}{35}$.

1, 1, 1

$5\times7=35$, the Least Common Denominator.

Reduce to Least Common Denominator.

3. $\frac{5}{7}$, $\frac{2}{14}$, $\frac{8}{11}$.
4. $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$.
5. $\frac{4}{5}$, $\frac{5}{17}$, $\frac{4}{35}$, $\frac{11}{34}$.
6. $\frac{17}{18}$, $\frac{23}{24}$, $\frac{15}{32}$.
7. $\frac{5}{8}$, $\frac{5}{24}$, $\frac{7}{12}$, $\frac{9}{144}$.
8. $\frac{4}{5}$, $\frac{5}{27}$, $\frac{4}{35}$, $\frac{13}{54}$.
9. $\frac{3}{10}$, $\frac{4}{15}$, $\frac{4}{20}$, $\frac{7}{30}$.
10. $\frac{7}{8}$, $\frac{3}{16}$, $\frac{5}{32}$, $\frac{7}{64}$.

ADDITION OF FRACTIONS

To add Fractions, reduce them to similar fractions, that is, to fractions having the same denominator, then add the numerators and place the sum over the common denominator.

1. Add $\frac{2}{3}$, $\frac{5}{8}$, $\frac{7}{4}$.

SOLUTION: $\frac{2}{3}+\frac{5}{8}+\frac{7}{4}=$
$\frac{16}{24}+\frac{15}{24}+\frac{42}{24}=\frac{73}{24}=\frac{1?}{8}=2\frac{?}{8}$. Ans.

Find the sum of:

2. $\frac{1}{4}$, $\frac{1}{8}$, $\frac{9}{16}$.
3. $\frac{5}{32}$, $\frac{19}{24}$, $\frac{5}{48}$.
4. $\frac{1}{8}$, $\frac{3}{32}$, $\frac{1}{64}$.
5. $\frac{1}{16}$, $\frac{17}{20}$, $\frac{29}{36}$.
6. $\frac{9}{8}$, $\frac{5}{24}$, $\frac{17}{18}$.
7. $\frac{4}{5}$, $\frac{5}{12}$, $\frac{11}{17}$, $\frac{23}{36}$.
8. $\frac{7}{8}$, $\frac{9}{10}$, $\frac{2}{3}$, $\frac{5}{6}$, $\frac{11}{12}$.

TO ADD MIXED NUMBERS

First add the Whole Numbers; then add the Fractions; then add the two results obtained.

Add:

1. $5\frac{1}{4}$, $7\frac{1}{8}$, and $6\frac{3}{4}$.

PROCESS:

$5\frac{1}{4} \quad \frac{1}{4}+\frac{1}{8}+\frac{3}{4}=$
$7\frac{1}{8}$
$6\frac{3}{4} \quad \frac{2}{8}+\frac{1}{8}+\frac{6}{8}+\frac{3}{8}=1\frac{1}{8}$.

18
$1\frac{1}{8}$

$19\frac{1}{8}$ Ans.

2. $2\frac{3}{8}$, $5\frac{2}{3}$, and $9\frac{1}{4}$.
3. $10\frac{3}{8}$, $12\frac{1}{3}$, and $7\frac{5}{18}$.
4. $13\frac{5}{8}$, $5\frac{5}{12}$, and $21\frac{5}{48}$.
5. $24\frac{3}{4}$, $32\frac{7}{8}$, and $21\frac{3}{24}$.

TO SUBTRACT FRACTIONS

Reduce to Similar Fractions and subtract the less numerator from the greater for a new numerator to be written over the common denominator.

1. Subtract $\frac{5}{8}$ from $1\frac{1}{12}$.

PROCESS:

$1\frac{1}{12}-\frac{5}{8}=\frac{22}{24}-\frac{15}{24}=\frac{7}{24}$. Ans.

Find the value of:

2. $\frac{5}{8}-\frac{3}{8}$ 7. $\frac{305}{368}-\frac{75}{64}$
3. $\frac{7}{12}-\frac{5}{8}$ 8. $\frac{11}{12}-\frac{5}{25}$
4. $\frac{17}{24}-\frac{11}{18}$ 9. $\frac{47}{170}-\frac{73}{78}$
5. $\frac{9}{10}-\frac{1}{2}$ 10. $\frac{5}{18}-\frac{4}{81}$
6. $\frac{23}{30}-\frac{7}{25}$ 11. $\frac{83}{84}-\frac{59}{72}$
12. $\frac{19}{100}-\frac{17}{1000}$

MULTIPLICATION OF FRACTIONS

To multiply a Fraction by a Whole Number, multiply the numerator of the Fraction by the Whole Number and write result over the given denominator, then simplify. Use cancellation.

1. Multiply $\frac{5}{12}$ by 15.

SOLUTION: $\frac{5}{12}\times 15=\frac{1}{12}\frac{5}{8}=11\frac{3}{4}$ or $11\frac{1}{4}$. Ans.

Multiply:

2. $\frac{5}{12}$ by 6.
3. $\frac{17}{24}$ by 4.
4. $\frac{7}{16}$ by 4.
5. $\frac{4}{15}$ by 5.
6. $\frac{3}{40}$ by 8.
7. $\frac{7}{12}$ by 6.

To multiply a Fraction by a Fraction multiply the numerators together for a new numerator and the denominators together for a new denominator. Use cancellation whenever possible.

1. Multiply $\frac{2}{3}$ by $\frac{14}{15}$.

SOLUTION: $\frac{2}{3}\times\frac{14}{15}=\frac{28}{45}$. Ans. Find the value of:

2. $\frac{5}{8}\times\frac{8}{10}$
3. $\frac{9}{7}\times\frac{21}{8}$
4. $\frac{15}{17}\times\frac{34}{35}$
5. $\frac{3}{8}\times\frac{4}{9}\times\frac{5}{12}$

DIVISION OF FRACTIONS

Reduce Whole Numbers to the form of Fractions, by writing 1 as their denominators. Reduce Mixed Numbers to Improper Fractions; then invert the divisor and multiply.

1. Divide 30 by $\frac{5}{12}$.

SOLUTION: $\frac{30}{1}\div\frac{5}{12}=$

$\frac{30}{1}\times\frac{12}{5}=72$. Ans.

Find the value of:

2. $\frac{3}{8}\div\frac{3}{4}$
3. $16\div\frac{2}{3}$
4. $20\div\frac{5}{4}$
5. $36\div\frac{6}{15}$
6. $4\frac{2}{11}\div\frac{9}{11}$
7. $\frac{7}{12}\div\frac{21}{18}$
8. $\frac{57}{8}\div\frac{38}{16}$
9. $576\div\frac{32}{7}$

DECIMALS

The Decimal Fraction always has a period called the *Decimal Point* at the left. The number of places in the Decimal is the same as the number of zeros in the denominator of the corresponding common fraction.

Thus $\frac{1}{10}$ equals .1; $\frac{6}{10}$ equals .6; $\frac{1}{100}$ equals .01; $\frac{25}{100}$ equals .25; $\frac{1}{1000}$ equals .001.

Notice that the number of zeros in the denominators of the above common fractions is the same as the number of figures to the right of the Decimal Point.

READING DECIMALS

The first place to the right of the Decimal point is *tenths'* place, the second *hundredths'* place, the third *thousandths'* place, the fourth *ten thousandths'* place, etc.

A Decimal is read just as if it were a whole number and is then given the name of the last Decimal place to the right.

Thus, .76 is read "seventy-six hundredths;" .0106 is read "one hundred six ten-thousandths."

Write the following as Decimals:

1. $\frac{1}{10}$; $\frac{1}{100}$; $\frac{6}{10}$; $\frac{9}{10}$; $\frac{47}{100}$; $\frac{75}{100}$; $\frac{3}{1000}$; $\frac{11}{1000}$; $\frac{9}{10,000}$.

2. Write as common fractions—nine-tenths; seven hundredths; eighty-five hundredths; twenty-nine hundredths; twenty-nine thousandths; twenty-nine ten-thousandths.

Mixed numbers are read with the word *and* between the whole number and the decimal. The number 975.3014 is read "nine hundred seventy-five *and* three thousand fourteen ten-thousandths." .275 is read "two hundred seventy-five thousandths," while 200.075 is read "two hundred *and* seventy-five thousandths."

3. Read: .7; 2.4; 90.03; 36.44; 216.5; 15.85.
4. Read: 86.09; 8.001; 60.044; 200.065; .265.
5. Read: 246.0012; 912.2006; 2000.0002; .2002.

CHANGING DECIMALS TO COMMON FRACTIONS

Any decimal may be changed to a common fraction.

Thus .6 equals $\frac{6}{10}$ equals $\frac{3}{5}$.

.25 equals $\frac{25}{100}$ equals $\frac{1}{4}$.

.875 equals $\frac{875}{1000}$ equals $\frac{7}{8}$.

.37½ equals 37½ 100, equals $\frac{75}{200}$ equals $\frac{3}{8}$.

Change to common fractions in the simplest form:

1. .8; .625; .375; .875; .225.
2. 37½; .87½; .12½; .06¼; .62½.
3. .83⅓; .33⅓; .66⅔.

Change the following common fractions to Decimals:

4. $\frac{1}{2}$; $\frac{1}{4}$; $\frac{3}{4}$; $\frac{1}{8}$; $\frac{5}{8}$; $\frac{7}{8}$; $\frac{1}{5}$; $\frac{3}{5}$; $\frac{4}{5}$.
5. $\frac{1}{10}$; $\frac{3}{10}$; $\frac{1}{20}$; $\frac{5}{12}$; $\frac{5}{8}$; $1\frac{1}{2}$; $\frac{3}{8}$.
6. $4\frac{1}{2}$; $2\frac{3}{8}$; $3\frac{7}{12}$; $8\frac{1}{2}$; $2\frac{3}{40}$.

ADDITION AND SUBTRACTION OF DECIMALS

Rule.—In adding or subtracting Decimals write the numbers so that the Decimal Points are in the same column and proceed to add or subtract as with integers or whole numbers. Place the Decimal Point in the sum or the difference under the Decimal Points above.

Add the following:

1. 2.25, .75, .1875, .0356.

```
 2.25
  .75
  .1875
  .0356
 ------
 3.2231
```

2. Add: .33 ⅓, 35.66 ⅔, 82¾, 1.201 ¼.

```
   .3375
 35.662
 82.75
  1.20125
 -------
127.95075
```

3. A girl spent for shoes $4.75, for ribbon $3.25, for a suit $30.75 and for the hat $5.50. What was her total bill?

4. A man owned 320 acres of land. He bought 30½ acres at one time and 12.41 acres at another time. How much had he in all?

MULTIPLICATION OF DECIMALS

Rule.—To multiply when there is a Decimal in either of both factors, multiply as with integers and point off in the product as many Decimal places as are found in both Multiplicand and Multiplier.

1. Multiply 24.6 by 10. Solution:

$$\begin{array}{r} 24.6 \\ \times\ 10 \\ \hline 246.0 \end{array}$$

2. Multiply 24.6 by 100. Solution:

$$\begin{array}{r} 24.6 \\ \times\ 100 \\ \hline 2460.0 \end{array}$$

NOTE.—In multiplying a Decimal by 10 the Decimal Point is moved one place to the right; multiplying by 100 moves the Decimal Point two places to the right; by 1000 three places, etc.

3. Multiply .3 by 6.75. Solution:

$$\begin{array}{r} .3 \\ \times\ 6.75 \\ \hline 15 \\ 21 \\ 18 \\ \hline 2.025 \end{array}$$

4. Multiply 225.5 by 5.0005.
5. 32½ by 1.0303.
6. .400 by 4.0635.
7. 9.3⅓ by 9.99.
8. When the average yield of corn is 23.9 bu. per acre and the price is 51¼ cents per bu., what is the average value of the corn crop per acre?
9. What will it cost to furnish 224.4 cu. yds. of sand at $1.25½ per cu. yd.?

DIVISION OF DECIMALS

Rule.—Provide as many Decimal places in the Dividend as you have in the Divisor by adding zeros if necessary. Divide as in whole numbers and point off as many Decimal places in the Quotient as there are Decimal places in the Dividend less the Decimal places in the Divisor.

1. Divide .095 by .5. Solution:

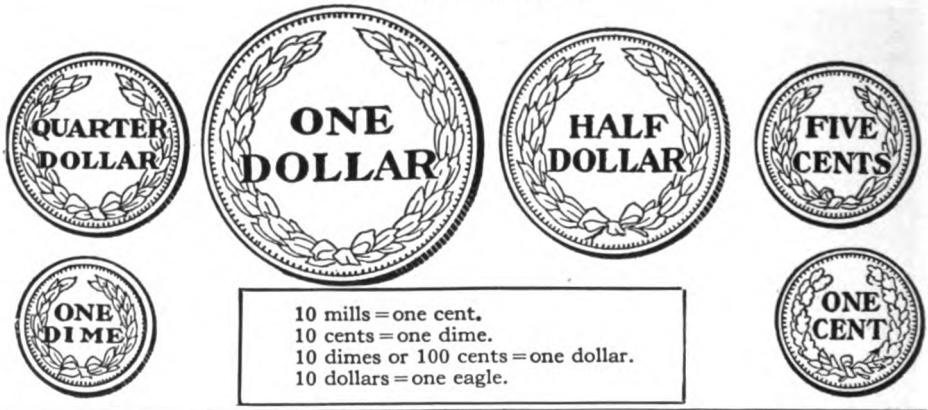
$$\begin{array}{r} .19 \\ .5\overline{)}.095 \end{array}$$

2. Divide 110.1 by .1101. Solution:

$$\begin{array}{r} 1000 \\ .1101\overline{)}110.1000 \end{array}$$

3. 1000 divided by .625.
4. 1.045 divided by .56.
5. If a telephone wire is worth $.002 per ft., what is the value of a telephone wire extending a distance of 5.75 miles?

UNITED STATES MONEY



10 mills = one cent.
10 cents = one dime.
10 dimes or 100 cents = one dollar.
10 dollars = one eagle.

BUSINESS APPLICATIONS OF DECIMALS

The solutions of many problems may be shortened by knowing the relation that the price of a unit bears to $1.

1. How much will 250 bu. of potatoes cost at $.25 per bu.?

Decimal Method.

$.25 = price
250 = no. of bu.

$$\begin{array}{r} 1250 \\ 50 \\ \hline 62.50 \end{array}$$

Short Method.

$$4\overline{)}250$$
$$62.50$$

EXPLANATION.—At $1 each 250 bu. would cost $250. At $¼ each they cost ¼ of $250 or $62.50.

Rule.—Find the cost of the quantity at $1 per unit, divide this by the quantity that can be purchased for $1.

Find cost of:

2. 90 bu. apples at 33⅓c per bu.
3. 32 lbs. butter at 25c per lb.
4. 640 yds. cloth at 6¼c per yd.
5. 75 lbs. lard at 12½c per lb.
6. 72 lbs. rice at 12½c per lb.

7. 120 yds. cloth at 37½c per yd.
8. 500 books at 40c each.
9. 600 doz. eggs at 25c per doz.
10. 300 bu. oats at 33⅓c per bu.
11. 800 bu. coal at 6¼c per bu.
12. 80 qts. cherries at 6¼c per qt.
13. 500 bu. corn at 40c per bu.
14. 180 lbs. beef at 10c per lb.

DENOMINATE NUMBERS

MEASUREMENTS

Distance, weight, time, liquids, etc., are measured by certain standard units of measure such as feet, pounds, hours, gallons.

LINEAR MEASURE

In measuring length or distance the measures are called Linear Measures.

If you do not know the following table, thoroughly learn it. Use a watch to see how few seconds you need for saying it.

TABLE OF LINEAR MEASURE

12	inches (in.) = 1 foot (ft.).
3	feet = 1 yard (yd.).
5½	yards = 1 rod (rd.).
320	rods = 1 mile (mi.).
5280	feet = 1 mile.

1. By measuring find the length and the width of your school room or your living room at home, in feet. In yards.

2. Estimate the length of a table. Then measure it and see how nearly right your judgment is.

3. Mark off what you think would be the length of a rod on the floor, and then measure the distance marked.

NOTE.—An expensive tape is not necessary for measuring long distances. Measure off and use a stout cord a rod long or fifty feet long. Every pupil should make many estimates of short and long distances followed by measurements of them to develop accuracy in judging distances.

REDUCTION IN LINEAR MEASURE

Changing any number of units of one denomination to units of another denomination is called *Reduction*.

EXERCISES

1. Reduce 10 miles to rods.

SOLUTION.—10 mi. × 320 = 3200 rods. Ans.

2. 4 rds. to feet.
3. 4 yds. 2 ft. to feet.
4. 2 mi. 248 ft. to feet.
5. 3 mi. 28 rds. to rods.

REDUCTION TO HIGHER DENOMINATIONS

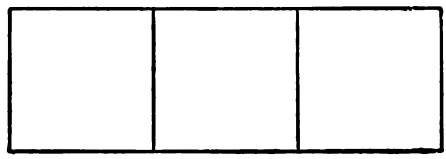
1. Reduce 96 in. to feet.

SOLUTION.—96 in. ÷ 12 = 8. Ans.

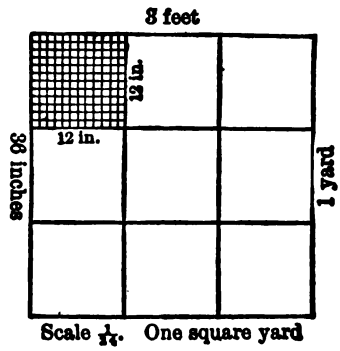
2. 54 ft. to yards.
3. 72 in. to yards; 288 in. to yards.
4. 15,840 ft. to miles; 1000 rds. to miles and rods.
5. Find the cost of digging a ditch ½ mile long at $2.75 a rod.

SQUARE MEASURE

Using your ruler draw upon the blackboard or a paper a square foot. Three square feet, thus.



Mark off all sides of this square foot with inch spaces and draw lines dividing the square foot into square inches. How many square inches in the square foot?



Scale 1/36. One square yard

Learn thoroughly the following table, using your watch to time yourself.

TABLE OF SQUARE MEASURE

144	square inches (sq. in.) = 1 square foot (sq. ft.).
9	square feet = 1 square yard (sq. yd.).
30¼	square yards = 1 square rod (sq. rd.).
160	square rods = 1 acre (A.).
640	acres = 1 square mile (sq. mi.).

1. The perimeter of a figure is the distance around it. What is the perimeter of your square foot?

2. Draw an oblong 6 inches long and 3 inches wide. Show that it contains 18 square inches.

3. How many square inches in a rectangle 8 inches long and 2 inches wide?

4. How do you find the area of any rectangle or square?

5. Draw figures showing the difference between a 6-inch square and 6 square inches.

6. Draw a square yard and divide it into square feet.

7. How many acres in a field 80 rds. long and 40 rds. wide?

8. What part of a square mile is a field 80 rds. by 40 rds.?

9. A township is six miles long and six miles wide. How many acres does it contain?

PROBLEMS ON PAVING

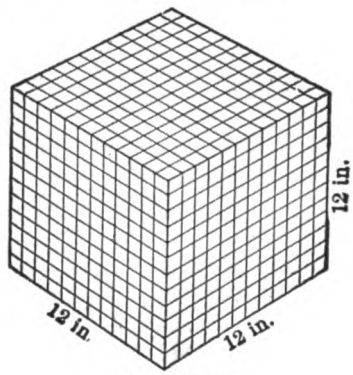
1. What is the cost of paving a walk 6 ft. wide in front of a 50-ft. residence lot, at 11 cents per foot?

2. What is the cost of paving a walk 7 ft. wide on two sides of a corner residence lot 50 ft. by 150 ft. at 9½ cents per square foot?

3. What is the cost of paving one-half of a 50-ft. street in front of a 50-ft. residence lot at 95 cents per square yard?

CUBIC MEASURE

A cube has *six faces* and each one is a *square*. If each face is a square inch, the cube is called a **cubic inch,** or a one-inch cube.



One cubic foot

Learn thoroughly the following table:

TABLE OF CUBIC MEASURE

1728	cubic inches (cu. in.) = 1 cubic foot (cu. ft.).
27	cubic feet = 1 cubic yard (cu. yd.).
128	cubic feet = 1 cord (for measuring wood).
24¾	cubic feet = 1 perch (for measuring stone).
1	cubic yard = 1 load (of earth).
231	cubic inches = 1 gallon (gal.).
2150.4	cubic inches = 1 bushel (bu.).

Rule.—To find the volume of a solid multiply together the length, breadth and thickness.

1. How many cu. ft. in a pile of wood 8 ft. long, 4 ft. wide, and 4 ft. high?

2. How many cords of wood in a pile 4 ft. wide, 8 ft. high and 32 ft. long?

3. How many gallons of water will a cistern hold which is 6 ft. × 10 ft. × 10 ft.?

4. A granary is 24 ft. long, 8 ft. wide, and 6 ft. high. How many bushels of wheat will it hold?

LIQUID AND DRY MEASURES

Learn thoroughly the following tables.

TABLE OF LIQUID MEASURE

4	gills (gi.) = 1 pint (pt.).
2	pints = 1 quart (qt.).
4	quarts = 1 gallon (gal.).
31½	gallons = 1 barrel (bbl.).
231	cubic inches = 1 gallon.

TABLE OF DRY MEASURE

2 pints (pt.) = 1 quart (qt.).
8 quarts = 1 peck (pk.).
4 pecks = 1 bushel (bu.).

Liquid measures

1. A grocer pays 20 cents a gallon for milk and retails it at 8 cents a quart. If he handles 40 gallons a day how much is his profit?

2. A ship with 1500 passengers aboard carries a supply of 15,000 gallons of fresh water. If each passenger on the average uses two quarts of water a day how long will the supply last?

3. A cistern holds 50 barrels of water. How many gallons is this?

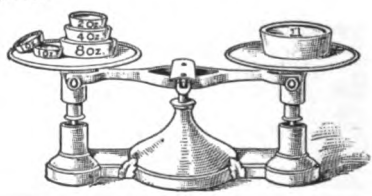
4. How many quart boxes will 4 bushels, 3 pecks, 1 quart fill?

5. What is the cost of 3 pecks, 3 quarts of nuts at 15 cents a quart?

6. If a half-peck basket of peaches sells for 25 cents how much will 4 bushels sell for?

AVOIRDUPOIS WEIGHT

Avoirdupois weight is used in weighing all heavy articles such as farm products, groceries, coal, etc.



16 ounces (oz.) = 1 pound (lb.).
100 pounds = 1 hundredweight (cwt.).
2000 pounds = 1 ton (T.).
196 pounds = 1 barrel (of flour).
280 pounds = 1 barrel (of salt).

NOTE.—The *long ton* (2240 pounds) is used in the United States Custom Houses and in wholesale dealings in coal and iron.

ADDITION AND SUBTRACTION OF DENOMINATE NUMBERS

1. Add 3 hours, 20 minutes; 5 hours, 10 minutes, 20 seconds; and 2 hours, 40 minutes and 42 seconds.

hrs.	min.	sec.
3	20	
5	10	20
2	40	42
11	11	2

42 sec. plus 20 sec. equals 62 sec., equals 1 min. 2 sec. 1 min. plus 40 min., plus 10 min., plus 20 min., equals 71 min., equals 1 hr. 11 min.

1 hr. plus 2 hrs. plus 5 hrs. plus 3 hrs. equals 11 hrs.

The answer is 11 hrs. 11 min. 2 sec.

2. Subtract 5 hours, 29 minutes, 25 seconds from 7 hours, 17 minutes, 47 seconds.

hrs.	min.	sec.
7	17	47
5	29	25
1	48	22

25 sec. from 47 sec. equals 22 sec. 29 min. from 1 hr. plus 17 min. or 77 min. equals 48 min.

5 hrs. from 6 hrs. equals 1 hr.

Ans.—1 hr. 48 min. 22 sec.

3.

bu.	pk.	qt.
4	2	5
17	3	3
10	2	6
26	3	5
5	1	3

4.

gal.	qt.	pt.
37	2	1
27	2	1
17	3	
28	2	2
27	0	1

5.

yd.	ft.	in.
8	2	11
4	1	8
12	4	5
9	1	1
6	0	8

6. From 200 gallons take 49 gallons, 3 quarts and 2 pints.

7. From 45 miles 121 rods, take 25 miles, 75 rods.

8. From 15 yards 2 feet and 2 inches, take 11 yards 1 foot 8 inches.

MULTIPLICATION AND DIVISION

1. Multiply 4 bushels 3 pecks 5 quarts by 4.

bu.	pk.	qt.
4	3	5
	×	4
19	2	4

4×5 qts. = 20 qts. = 2 pks. 4 qts.

4×3 pks. + 2 pks. = 14 pks. = 3 bu. 2 pks.

4×4 bu. + 3 bu. = 19 bu.

Ans.—19 bu., 2 pks., 4 qts.

2. Divide 69 feet 4 inches by 8.

ft.	in.
8)69	4
8	8

69 ft. divided by 8 = 8 with a remainder of 5 ft.

5 ft. (60 in.) + 4 in. = 64 in.

64 in. ÷ 8 = 8 in.

3. If a horse eats two pecks of oats a day how long will 60 bushels last him?

NOTE.—Reduce both terms to pecks and divide.

4. If an acre will produce 16 bushels 3 pecks of wheat, how many bushels will 40 acres produce at the same rate?

5. A farmer thrashed 4400 bushels of oats, how many sacks, each holding 3 bushels 4 quarts will be required to contain his crop?

PERCENTAGE

Per cent means per hundred. Thus, 10% means 10 in each 100.

10% = .10 = $\frac{10}{100}$ or $\frac{1}{10}$.

1. 50% of anything is what part of it?
   50% = .50 = $\frac{50}{100} = \frac{1}{2}$.
2. 25% of anything is what part of it?
   25% = .25 = $\frac{25}{100} = \frac{1}{4}$.
3. 12½% = $\frac{1}{8}$ of 25% or $\frac{1}{8}$.

It is often convenient in solving problems in percentage to change the per cent to a common fraction. Therefore every pupil should memorize thoroughly the following table.

Table of Equivalents

$\frac{1}{2}$ = 50%	$\frac{1}{3}$ = 33⅓%
$\frac{1}{4}$ = 25%	$\frac{2}{3}$ = 66⅔%
$\frac{1}{8}$ = 12½%	$\frac{1}{6}$ = 16⅔%
$\frac{1}{5}$ = 20%	$\frac{1}{8}$ = 80%
$\frac{2}{5}$ = 40%	$\frac{3}{4}$ = 75%
$\frac{3}{5}$ = 60%	$\frac{3}{8}$ = 37½%

Other Equivalents Less Important Are

$\frac{5}{6}$ = 83⅓%	$\frac{5}{8}$ = 62½%
$\frac{1}{7}$ = 14$\frac{2}{7}$%	$\frac{7}{8}$ = 87½%
$\frac{1}{12}$ = 8⅓%	$\frac{1}{16}$ = 6¼%

1. Find 25% of 16. Of 24. Of 48.

SOLUTION.—25% = $\frac{1}{4}$.

$\frac{1}{4}$ of 16 = 4.

2. Find 33 1/3% of 24. Of 36. Of 72.
3. Find 66 2/3% of 24. Of 36. Of 72.
4. Find 20% of 40. Of 60. Of 80.
5. Find 40% of 50. Of 60. Of 80.
6. Find 50% of 17. Of 21. Of 34.
7. Find 75% of 12. Of 16. Of 36.
8. Find 80% of 10. Of 20. Of 40.
9. Find 37 1/2% of 16. Of 48. Of 32.
10. Find 30% of 80. Of 40. Of 50.
11. 18 is what % of 24? Of 36? Of 54?

SOLUTION.—18 ÷ 24 = $\frac{18}{24} = \frac{3}{4}$ = 75%.

12. 24 is what % of 48? Of 72? Of 12?
13. 12 is what % of 16? Of 18? Of 84?
14. 25 is what % of 50? Of 75?
15. 35 is what % of 40? Of 42? Of 70?
16. Write as *Decimal Fractions* the following: 5%, 8%, 2%, 12%, 60%.

SOLUTION.—5% = $\frac{5}{100}$ = .05.

17. 80%, 90%, 17%, 15%, 14%.
18. $12\frac{1}{2}\%$, $14\frac{1}{8}\%$, $16\frac{2}{3}\%$, $\frac{1}{2}\%$, $\frac{1}{8}\%$.
19. Express as per cents, $\frac{1}{2}$, $\frac{1}{5}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{3}$, $\frac{1}{7}$, $\frac{1}{6}$, $\frac{1}{9}$, $\frac{1}{10}$.
20. Express as per cents, $\frac{3}{10}$, $\frac{4}{5}$, $\frac{2}{5}$, $\frac{5}{6}$, $\frac{3}{8}$, $\frac{5}{8}$, $\frac{7}{8}$.

ORAL PROBLEMS

1. A man planted 20% of his 640-acre farm with wheat. How many acres of wheat had he?
2. A man planted 160 acres of corn. His farm contained 640 acres. What per cent of his farm was planted to corn?
3. A man owning a half section of land leaves 25% of it for pasture. How many acres are in pasture?

WRITTEN PROBLEMS

1. In a storm at sea 72% of the 3000 passengers on board an ocean liner were drowned. How many people were lost?
2. A dealer lost 75 bbls. of apples or 15% of all he handled. How many bbls. did he handle?
3. A man bought a lot for $3000 and held it for 2 years, selling it at a gain of 17%. Find the selling price.
4. A man bought a lot for $1600 and sold it for $1400. What was his loss per cent?

INTEREST

Money paid for the use of money is called *Interest.* Interest is a certain per cent of the amount borrowed which latter is called the *Principal.* The per cent charged for the use of the money is called the *Rate.*

ORAL DRILL

1. At 5% how much is the interest on $200 for 1 year? For 6 months? For 2 years? For 2 years 6 months?
2. At 6% find the interest on $400 for 1 year. For 8 months or $\frac{2}{3}$ of a year? For 2 years? For $2\frac{1}{2}$ years?
3. At 4% what is the interest on $800 for 1 year? For 6 months? For 3 months? For 9 months? For a year and 9 months?

WRITTEN EXERCISES

4. At 5% what is the interest on $640 for 2 years 5 months?

SOLUTION: $\frac{29}{12} \times \frac{5}{100} \times 640$ or

$$\frac{29 \times 5 \times 640}{12 \times 100} = \$77.33$$

EXPLANATION.—$\frac{5}{100}$ of $640 equals the interest for 1 year. Two years 5 months equals $\frac{29}{12}$ years, therefore the total interest equals $\frac{29}{12} \times \frac{5}{100} \times 640$. Use cancellation whenever possible.

5. Find the interest of $250 at 4% for 1 year 4 months.
6. Find the interest of $500 at 5% for 1 year 3 months.
7. Find the interest of $750 at 4% for 2 years 2 months.
8. Find the interest of $124 at 6% for 1 year 9 months.
9. Find the interest of $436 at 5% for 2 years 8 months.

NOTE.—In the above problems no days are given. But where the time of the problem has days, reduce the time to days as a numerator over 360 days.

10. Find the interest of $6500 at 6% for 3 months 20 days.

SOLUTION: 3 months 20 days = 110 days.

$$\frac{110}{360} \times \frac{6}{100} \times \$6500 = \$119.17.$$

11. Find the interest of $650 at 5% for 70 days.
12. Find the interest of $135 at 5% for 8 months 20 days.
13. Find the interest for $486 at 4% for 90 days.

THE BANKERS' METHOD OR THE 60-DAY METHOD OF FINDING INTEREST

Money is often borrowed for short periods especially at banks for 30, 60 or 90 days. Six per cent is a very usual rate in such cases. The method used is as follows:

The interest of any Principal at 6%:
For 360 days = 0.06 of the Principal.
For 60 days = 0.01 of the Principal.
For 6 days = 0.001 of the Principal.

14. Find the interest of $660 at 6% for 90 days.

SOLUTION: Interest for 60 days = $6.60
For 30 days = 3.30
Total interest $9.90

EXPLANATION.—Since $\frac{1}{100}$ of $660 or $6.60 is the interest for 60 days and 30 days equals half as much, or $3.30, the total interest must be their sum.

Find the interest at 6% of:

15. $1080 for 60 days.
16. $720 for 90 days.
17. $840 for 30 days.
18. $960 for 10 days.
19. $480 for 45 days.

Find the interest at 6% of:

20. $1440 for 87 days.

SOLUTION: $14.40 = interest for 60 days.
4.80 = interest for 20 days.
1.20 = interest for 5 days.
.48 = interest for 2 days.
$20.80 — 87 days.

21. $2400 for 50 days.
22. $1500 for 120 days.
23. $2750 for 63 days.
24. $840 for 84 days.
25. $3040 for 108 days.

Note that the foregoing problems all bear 6%. This method may be used with problems bearing any per cent.

26. At 5% find the interest of:
$1680 for 75 days.

SOLUTION:

$16.80 = the interest at 6% for 60 days.
4.20 = the interest at 6% for 15 days.

6)$21.00 = the interest at 6% for 75 days.

$ 3.50 = the interest at 1% for 75 days.
17.50 = the interest at 5% for 75 days.

27. $1640 for 70 days.
28. $1900 for 63 days.
29. $1750 for 72 days.

TAXES

Towns, cities, counties and states meet most of their expenses by levying taxes upon the property within their limits.

For purposes of taxation property is divided into two classes, Real Estate and Personal Property.

Real Estate is immovable property such as land including mines, quarries, forests, railroads and buildings.

Personal Property is movable property such as money, stocks, bonds, household goods, cattle, etc.

Some states also levy a tax on all male citizens over twenty-one years old. This is called a *Poll Tax*.

Name some ways in which your city or county spends its tax money.

METHOD OF SPREADING TAXES

Officers called *Assessors*, first inspect property and place a value upon it for taxation. Then the city, township, school district or county determines the amount of money needed to run the government for one year. The total amount of money needed is divided by the total value of the property as fixed by the Assessor. This gives the amount of tax on one dollar or the rate of taxation.

Thus if a school district needed $20,000 to run its schools for 1 year while the property in the district was valued by the Assessor at $2,000,000, the rate would be $20,000 ÷ $2,000,000 = .01, which is the rate of taxation for school purposes.

1. If the Taxes are 18 mills on $1, what rate per cent are the Taxes? How much are the Taxes on property valued at $15,000?

2. My property is assessed at $5000, the Tax rate is 1½%. What are my annual Taxes?

3. What would be the Tax on a farm assessed at $6000 if the rate is .007? If it is .0102?

4. Mr. Jones owns a house valued at $24,000 which is assessed at 2/3 of its value. The Tax rate is .022. What will be his total Tax?

5. If Mr. Jones pays his Tax within thirty days he receives a discount of 2%. How much will he save by paying his Taxes promptly?

PROPERTY INSURANCE

A man who does not wish to bear the total loss of his house in case of fire pays an *Insurance Company* a certain per cent for the Insurance of his property. The amount paid is called the *Premium*.

The Insurance Company agrees to make good his loss to the extent of the sum named in the *Policy* or contract with him in case his house is accidentally burned during the period covered by the Policy.

Insurance Companies do not usually insure property for its full value. Can you give a reason why?

1. The school house is insured for $10,000 for three years. The Board of Education has to pay the Insurance Company 50% for this. What is the face of the Policy? What per cent of the face of the Policy is the Premium? What per cent is this a year?

2. I value my house at $10,000. The Company insures it for 3 years at half its value at ¼% of the face of the Policy. How much will the Premium cost?

3. A business block costing $40,000 is insured for 3 years for ½ its value at 1% a year. What is the total Premium?

4. A hotel is insured for $10,000 in each of five different companies. The total Premium is $1000. Find the rate of insurance.

5. A factory worth $80,000 is insured for ¾ of its value at 1¼%. In case of total loss by fire find the owner's loss, including Premium paid out.

COMMISSION

The value of property.—City property varies greatly in price depending upon the city and upon whether the property is used for residence for business blocks, or for factories. The distance from street cars or other means of transportation affects the value of property. City lots are valued at so much per front foot.

The width of a lot measured along the street is its *Frontage*, while the distance from the street to the rear of the lot is called its depth. If it is worth $20 per front foot that means $20 for a strip one foot wide at the street and reaching back to the rear of the lot. The deeper the lot the more area it covers and the more desirable it is, other things being equal. When one speaks of a 100-foot lot, one means a lot with 100 feet frontage.

Residence lots vary in frontage from 30 feet in poorer sections to 150 feet or more in the best residence districts. In depth they may be from 100 feet to 200 feet or more. The price of residence lots varies in different cities and in different districts of the same city from $15 or $20 to $200 or more per front foot.

1. What are vacant lots near your home valued at per front foot? At that rate what is an 80-foot lot worth?

2. Who pays for laying sidewalks in front of a property? Who pays for paving the street and laying the sewer? See if you can find out how much it costs per front foot to do these things on your street.

PRACTICAL PROBLEMS AND CALCULATIONS

EDUCATION AND INDUSTRY

It has been carefully estimated that a man with a common school education is able to produce on the average 1½ times as much wealth as an unschooled man; the high school man can produce 2 times as much, and the college man 4 times as much as the untrained mind.

If a laborer who can neither read nor write is able to earn $14 a month, how much more should he earn in a period of 40 years if he had started with a common school education? Ans.—$3360.

How much more would he have accumulated in the same time if he had obtained a high school education? Ans.—$13,440.

What will be the difference in the earnings of two men for a work period of 40 years, one with a college education who earns $1000 a year and the other with a common school education who earns $450 a year? Ans.—$22,000.

A boy who knows how to handle and care for tools saves in this way 5 cents for every work day he lives. What is this training worth to a man in the course of 40 years if there are 26 working days in each month? Ans.—$624.

A boy who has been trained in the use of tools saves $20 a year in the repairs and convenient articles made for the home. What does this amount to in 40 years? Ans.—$800.

A self-binder costing $125 would have lasted with good care 12 years. It was left out in the weather and lasted only 8 years. What did the farmer's carelessness cost him? Ans.—$93.75.

If a careless hired hand while cultivating corn covers up 20 hills to the acre, what is the value of the corn destroyed on a 20-acre field, counting 2 ears to a hill and 100 ears to the bushel when corn is worth 50 cents a bu.? Ans.—$4.

FENCING

DATA.—Barbed wire is sold by the roll, weighing about 100 lbs. and containing about 1200 ft. of wire. In a pound of staples there are about 100.

NOTE.—Always draw the form of the field before attempting to solve the problem.

How much wire fencing will it take to fence an acre lot in the form of a square, 12 rods, 10 ft., 9 in. each way? Ans.—50 rods, 10 ft.

How much fence will it take to enclose an acre lot which is 20 rods long and 8 rods wide? Ans.—56 rods.

A 40-acre field is 80 rods each way. Find cost of posts and fencing with three strings of barbed wire at 25 cents a rod and a 12-foot gate worth $5. Ans.—$85.

Another 40-acre field is 160 rods long and 40 rods wide, how much more will the fence cost than in the previous problem with the posts, fence and gate at the same price? Ans.—$20.

How much more will the fence posts cost for the 40-acre tract 160 rods by 40 rods than for the same acreage in the form of a square if the posts cost 8 cents each and are placed 1 rod apart, one extra being necessary for the gate? Ans.—$6.40.

How many acres of land in a field 80 rods wide and 120 rods long? How many rods of fencing are needed to enclose it? Ans.—60 acres; 400 rods.

How many rods of fencing are required per acre in the above problem? Ans.—5 rods.

How many acres of land in a field 40 rods square? Ans.—10 acres.

How many rods of fencing are needed to enclose a field 40 rods square? Ans.—160 rods

How many rods of fencing are required per acre in a field 40 rods square? Ans.—16 rods.

If the fencing costs 30 cents a rod and lasts 10 years, what is the yearly cost per acre? Ans.—30 cents an acre per year.

How much is the annual cost per acre of such a fence if 10¾ rods of fence are required to enclose an acre? (See above problem.) Ans.—32 cents per acre per year.

What does it cost for posts worth 12 cents each to build 120 rods of fence if the posts are set 1½ rods apart? Ans.—$9.60.

CORN

HOW TO TEST SEED CORN.—Make a box 36 in. by 40 in. and 3 in. deep. Fill the box about half full of moist dirt, sand or sawdust. Press it down so that it will have a smooth, even surface.

Take a white cloth about the size of the box, rule it off into squares 3 in. each way, numbering them 1, 2, 3, 4, etc., and place it in the box upon the sand. Take 6 kernels from each ear and place in one square, giving the ear the same number. Cover with a moist pad stuffed with sawdust and keep moist and warm for several days.

How many days did corn planted May 10 have to mature if frost occurred on the night of September 10? Ans.—123 days.

When corn is planted May 15 and frost comes on the night of September 1, how many days has the corn in which to mature? Ans.—108 days.

A bushel of seed corn will plant 7 acres. When seed is selling at $2 a bu., what is the cost of seed per acre? Ans.—28 4/7 cts.

If extra good seed corn costs $4.50 a bu., what will it cost per acre? Ans.—64 2/7 cts.

If it costs 14 cts. a bu. to grade seed corn with a corn grader and a bu. of corn will plant 7 acres, what is the cost per acre for grading the seed? Ans.—2 cts.

If a man spends 4 hours shelling off tip and butt kernels and sorting irregular kernels from a bu. of seed corn, how much will it cost him per acre if his time is worth 15 cts. an hour? Ans.—8 4/7 cts.

If it requires 18 ears of corn to plant 1 acre, how many ears would be needed to plant 12½ acres? Ans.—225 ears.

Corn on the ear weighs 70 lbs. a bu. If the ears average 10 oz. each, how many ears in a bu.? Ans.—112 ears.

If the ears average 12 oz. each, how many ears in a bu.? Ans.—93 plus ears.

If a man can select 1120 ears of seed corn averaging 10 oz. each in 3 days, how much will it cost him a bu. if his time is worth $2 a day? Ans.—60 cts.

What are 1120 ears of seed corn worth at $2.50 a bu. if the ears average 10 oz. and there are 70 lbs. in a bu.? Ans.—$25.

Corn is sometimes reckoned on the basis of 120 ears to the bu. What is the weight of such corn per ear? Ans.—9⅜ oz.

If corn is planted in check rows 3 ft. 8 in. apart each way, how many square feet does each hill of corn occupy? How many hills on an acre? Ans.—13⅔ sq. ft.; 3240 hills.

How many stalks are there on an acre when they are planted 3 stalks in a hill 3 ft. 8 in. each way? Ans.—9720 stalks.

If the stand is perfect and each stalk produces one ear, what is the yield per acre, 120 ears to the bu.? Ans.—81 bu.

A bushel of choice seed corn costing $3.50 a bu. will plant 7 acres in check rows. What is the cost of the seed for 20 acres? Ans.—$10.

A poorer quality of seed will be priced at $1.50 a bu. How much less will it cost for the same 20 acres? Ans.—$4.29.

After shelling off the irregular kernels on the butt and tip of a certain ear of corn there are 38 kernels left in each row. If there are 20 rows on the cob how many hills will it plant, placing 3 kernels in a hill? Ans.—253 hills.

DRAINAGE

All tile are 1 foot long. The average price is about 3 cents each for 3-in. tile, 4 cents each for 4-in. tile and 5 cents each for 5-in. tile.

A tract of wet land of 17 acres was tile-drained at a cost of $24 an acre. What was the cost of draining the field? Ans.—$408.

The farmer then sowed it to wheat, harvesting 45 bu. an acre, which sold for one dollar a bushel. What was his gross income from the wheat crop? Ans.—$765.

If the farmer cleared 33⅓ cts. a bu. from his wheat crop, of 45 bu. an acre each year, what would be his net gain in 5 years after deducting the cost of tiling? Ans.—$867.

Mr. Brown had a square piece of low land containing 90 acres. When he prepared to tile it he found it was 6 ft. 8 in. higher at one side than at the other. How wide is the field? How much fall will this be to the rod? Ans.—120 rods wide; 1½ in. to the rod.

What did it cost to lay 6 strings of tile across this 90-acre tract if the tile is $20 a thousand and each tile was 1 ft. long and the cost of laying them was 30 cts. a rod? Ans.—$453.60.

Find the cost per acre for tiling. Ans.—$5.04.

If tiling Mr. Brown's field increased the yield of corn an average of 8 bu. per acre, what will the increase of corn be worth on the 90 acres at 40 cts. a bu. in 10 years? Ans.—$2880.

What will be the net gain per acre over the cost of tiling in 10 years? The net gain on the 90-acre tract? Ans.—$26.96 an acre; $2426.40.

Farmer Jones had 20 acres of orchard with 30 trees on each acre. Each tree yielded on the average 2 bbls. of apples worth $3 a bbl. After tile-draining his orchard at a cost of $30 an acre, his income from the crop was doubled. What fraction of the crop paid for the tiling? Ans. 1/12 of the crop.

PLOWING

There are 160 sq. rds. in an acre. How many acres in a field 80 rods square? Ans.—40 acres.

How many acres in a field 8 rods wide and 20 rods long? Ans.—1 acre.

A ten-acre field is 40 rods long. How many feet wide is it? Ans.—660 ft.

A five-acre field is 16 rods wide; how long is it? Ans.—50 rods.

How many times must a farmer cross a field 40 rods square with a harrow 12 ft. wide to harrow the field? Ans.—55 times.

How far will the farmer travel in the above problem? Ans.—6⅞ miles.

How many times must Mr. Brown cross a field 16 rods wide with a 12-foot harrow to harrow the field? Ans.—22 times.

How many rounds (back and forth) must Mr. Brown make to plow a field 8 rods wide if the plow turns a furrow 14 in. wide? Ans.—57 rounds.

How far must the plowman, cutting a 14-in. furrow travel to plow an acre 8 rods wide, not counting the turns? Ans.—7⅛ miles.

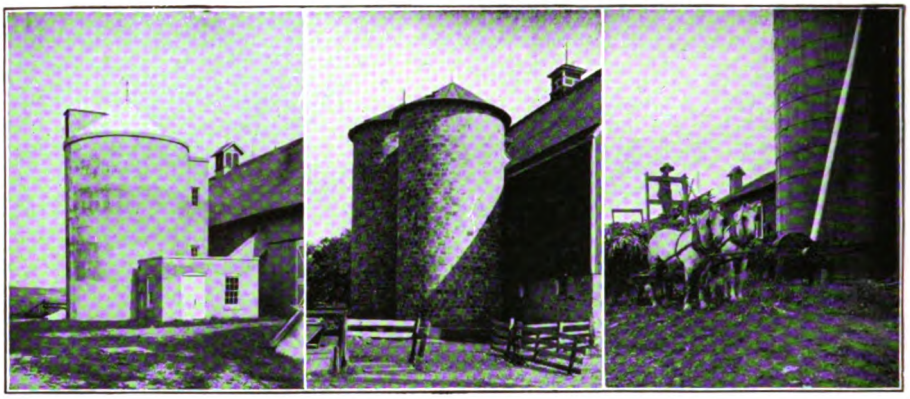
How far must one travel with a 12-foot harrow to harrow an acre? Ans.—220 rods.

How far must a team travel, not counting the turns, to plow one round on a field 40 rods long? Ans.—¼ mi.

To plow a strip 10 rods wide, how many furrows must be plowed with a 14-in. plow? Ans.—142 furrows.

How far must a team travel to plow a field 20 rods square with a 14-in. plow? Ans.—17⅛ mi.

A man with two horses and a 14-in. plow plows 2 acres in 8 hours. What does it cost to plow one acre if the man's time is worth 16 cts. an hour and the time of each horse is worth 8 cts. an hour?—Ans.—$1.28.



SILOS

The base of a silo is 20 ft. in diameter. Find its circumference. Ans.—62⅔ ft.

Find the capacity in cu. ft. of a silo 16 ft. in diameter and 30 ft. high. Ans.—9428⅔ cu. ft.

If a cu. ft. of silage weighs 30 lbs., how many tons will this silo contain if after it is settled the silage is 4 ft. from the top? Ans.—122 .5 T.

A silo is 18 ft. in diameter and 32 ft. high; how many tons of silage does it hold if a cu. ft. weighs 36 lbs. and it has settled 4 ft. from the top? Ans.—123.3 T.

If 45 cows are fed 36 lbs. each of silage a day, how long will the contents of the above silo last this herd? Ans.—158 days.

What must be the diameter of a silo 36 ft. deep filled with silage to within 4 ft. of the top to hold enough silage to feed 24 cows 35 lbs. a day for each cow for 180 days if the silage weighs 36 lbs. a cu. ft. Ans.—13 ft, nearly.

How many acres of corn will it take to supply ensilage to a herd of 24 cows for 180 days, 35 lbs. each per day, if 1 acre yields 12 T. of silage? Ans.—7 acres, nearly.

The corn on a field of 24 acres when ready for cutting and chocking, or for putting in the silo, weighs 10 tons per acre, of which 80% is water. By cutting and shocking the corn there is a loss in dry matter of 30%; by putting it in the silo there is a loss in dry matter of only 10%; if the dry matter in silage is worth $.0071 a lb., what is the value of the feed gained by putting the crop in the silo? Ans.—$136.32.

A silo 16 ft. in diameter is filled 24 ft. deep with silage. One cu. ft. weighs 30 lbs. How many tons of silage are in the silo? Ans.—144.8 T.

HAY

One acre of mixed clover and timothy will produce 2½ tons of hay. If the labor to raise it costs $3.68 an acre and the rent of the land is $2.50 an acre, what is the total cost per ton? Ans.—$2.47.

If the above crop yields but 1½ tons an acre what is the cost per ton for producing it? Ans.—$4.12.

If bran is worth 2½ times as much as clover hay per pound, how much is bran worth when clover is $8 a ton? Ans.—$20.

If it costs a farmer only $3.34 a ton to raise clover hay, how much can he afford to pay for bran which is worth 2½ times as much as clover hay? Ans.—$8.35 a ton.

If a 12-acre field of clover yields 3500 lbs. of hay per acre at the first crop, and a bushel of seed per acre at the second crop, what is the entire yearly income from the field when hay is $10 a ton and seed $8 a bu.? Ans.—$306.

At $8 a bu. what is the return from 5 acres of clover yielding 160 lbs. of seed an acre (60 lbs. to the bu.). Ans.—$106.66⅔.

If an acre of clover yields 4500 lbs. of clover hay the first cutting and 2400 lbs. the second cutting, what is the value of the crop at $8 a ton? Ans.—$27.60.

One pound of alfalfa hay contains .11 of a pound of digestible protein, .4 of a pound of carbohydrates, and .012 of a pound of fats. Red clover hay contains .068 lb. protein, .36 lb. carbohydrates and .017 lb. fats. What is the difference in the feeding value of a ton of alfalfa and a ton of red clover when digestible protein is worth 3 cts. a lb. and carbohydrates 1 ct. a pound and fats 2½ cts. a pound? Ans.—Alfalfa $15.20 per ton; red clover $12.13.

One pound of timothy hay contains .028 lb. digestible protein, .43 lb. C. H., and .014 lb. fat. Which has the greater feeding value, timothy or clover according to the above problem? Ans.—Clover, $12.13; timothy, $10.98.

ORCHARDS AND SPRAYING

When trees are set 25 ft. apart each way, how much space does each tree occupy and how many trees can be set on an acre 10 rods by 16 rods? Ans.—60 trees.

(NOTE.—Find how many trees in a row and the number of rows.)

If the acre lot is square how many trees may be set on it 25 ft. each way? Ans.—64 trees.

If there are 64 trees per acre and each tree produces 3 bu. 3 pk. of apples, how much are the apples on one acre of orchard worth at 75 cts. a bu.? Ans.—$180.

The Kentucky Experiment Station made a spraying test on an orchard that had never before been sprayed. One sprayed Maiden Blush tree yielded 7 bu. of apples, 4½ bu. of which graded firsts and sold at 75 cts. a bu., the remainder graded seconds and sold at 37½ cts. One unsprayed tree of the same variety in the next row yielded 4 bu. of apples, ½ of which graded firsts and the rest seconds. What is the difference in income from the fruit on the two trees? Ans.—$2.625.

If an orchard contained 200 trees, what would be the difference in income from a sprayed and an unsprayed crop according to the data in the above problem if firsts sold at 50 cts. a bu. and seconds at 30 cts.? Ans.—$340.

Bordeaux Mixture contains 4 lbs. of freshly slaked lime and 4 lbs. of copper sulphate or bluestone in 50 gals. of water; with lime at 1c. a pound, and copper sulphate at 10 cts. a pound, what would it cost to spray 200 apple trees twice if 2 gals. of the mixture is sufficient for the spraying of one tree once? Ans.—$7.04.

Three unsprayed apple trees yielded 188 sound apples while 6 similar trees, sprayed, yielded 8764 sound apples. Counting 100 apples to the bushel, what would be the gain from spraying 100 trees when apples are selling at 80 cts. a bu.? Ans.—$1118.40.

FEEDING

If a calf weighs at birth 55 lbs. and gains 2 lbs. a day, what should it weigh under usual conditions at the end of 90 days? Ans.—235 lbs.

When milk is worth 15 cts. a gal., what is the cost of making a calf that weighs 60 lbs. at birth weigh 140 lbs. when it takes 1½ gals. of milk to produce one pound of his weight? Ans.—$15.

Which is the better proposition, to keep a young calf for 90 days, feeding it on the average 2½ gals. of milk a day worth 10 cts. a gal., and then sell it for $15; or to sell it at birth for $3 and sell butter-fat from the milk at 18 cts. a pound if the milk contains 3.8% butter-fat and a gal. of milk weighs 8.6 lbs.? Ans.—First proposition, loss $7.50; second, gain $8.88.

A calf at birth weighs 68 lbs. If at the end of 60 days it weighs 200 lbs., what is the cost of its keep, not counting labor, if 1½ gal. of milk worth 15 cts. a gal. produces 1 lb. of weight? Ans.—$24.75.

At an Experiment Station a certain pig that was fed a total of 397 lbs. of shelled corn gained 79 lbs. At this rate how many pounds of shelled corn did it take to produce one pound of flesh? Ans.—5 lbs. corn.

When corn is 50 cts. a bu., what does it cost to add one pound of flesh to a pig according to the above problem (56 lbs. to a bu.)? Ans.—$4\frac{8}{11}$ cts.

At this rate how many pounds of fat can be put on a hog with a bushel of corn weighing 56 lbs.? Ans.—11 lbs.

Another test showed that pigs fed for 46 days on a total of 334 lbs. of middlings gained 90 lbs. At this rate how many pounds of middlings does it take to put one pound of flesh on a hog? Ans.—3.7 lbs.

Compare the cost of producing one pound of live weight on a hog with corn at 45 cts. a bu. with middlings at $1.40 a cwt. Ans.—Corn $4\frac{1}{11}$ cts; middlings $5\frac{5}{77}$ cts.

ROADS

Farmers living in regions where they have good roads are enabled to haul their products to market at any season of the year. Larger loads can be drawn in less time. This reduces the cost of marketing crops. A good road must be hard and smooth with proper slope for drainage.

If a road is 66 ft. wide, how many sq. ft. of surface are there in a mile of road? Ans.—348,480 sq. ft.

If a road bed is 12 ft. wide, how many square feet of surface in a mile? Ans.—63,360 sq ft.

If there are 32 in. of rainfall in a year, how many tons of water fall on a mile of road 66 ft. wide, in a year? Ans.—3833.28 T.

How many cu. yds. of gravel are required to cover a mile of road bed 10 ft. wide and 6 in. deep? Ans.—977⅞ cu. yd.

If it costs 50 cts. a sq. rd. for grading, what will it cost to grade a mile of road-bed 10 ft. wide? Ans. $96.93.

If a team can be hired for $4 a day of 10 hrs. each which can haul a cu. yd. of gravel an hour, how long will it take to gravel a 12-foot road-bed a mile long with gravel 6 in. deep? What will it cost? Ans.—$469.33.

An apple grower had 1200 tons of apples to deliver to the railroad 6 miles away. It is estimated that poor dirt roads cost the marketer 17 cts. a ton for every mile. In this region the roads were well-kept and the cost was only 13 cts. a mile. How much does this grower save on his crop by the good roads? Ans.—$288.

According to the above problem, what does it cost Mr. Carter to market 60 tons of produce at a distance of 6 mi. on poor dirt roads? Ans.—$61.20.

Mr. Bangs goes to market twice a week. The market is 10 miles away. Over poor roads a whole day is consumed. Over macadamized roads he can make the round trip in half a day. How much would macadamized roads save this farmer in a year if the time of himself and his team is worth $2 a day? Ans.—$104.

RENTS

Property owners usually charge their tenants 10% of the value of the house and lot as rent. Out of this gross rental the owner pays the taxes, insurance and the necessary repairs. These three items average about ⅛ or 20% of the gross rental.

Real estate agents charge from 2½% to 5% of the gross rental as commission for renting a house for an owner. For selling of property agents charge from 2½% to 5% of the selling price of the property for their services.

For what would a man owning a $10,000 house on an average lot be likely to rent it?

WHEAT

How many bushels in 13,620 lbs. of wheat if there are 60 lbs. in a bushel? Ans.—227 bu.

How many pounds are produced on 12½ acres yielding 20 bu. per acre? How many bushels? Ans.—15,000 lbs.; 250 bu.

If there are 12 lbs. of water in 100 lbs. of wheat, how many pounds of water in 25 bushels? Ans.—180 lbs.

If $\frac{7}{10}$ of wheat is starch, how many lbs. of starch in 25 bu.? Ans.—1350 lbs.

How many tons of wheat are grown on 24 acres yielding 24 bu. per acre? Ans.—17.2 tons.

What is the value of the crop in the above problem at 85 cents a bushel? Ans.—$489.60.

It takes 4.77 bu. of wheat to make one bbl. of flour. How many bbls. of flour can be made from a 20-acre field of wheat averaging 15 bu. to the acre? Ans.—62.9 bbls.

If 60 acres are seeded to wheat and only $\frac{4}{5}$ of the seed germinates, how many acres are seeded to wheat that will not grow? Ans.—12 acres.

At 85 cts. a bu. and with a crop of 24 bu. per acre, what is the value of the wheat grown on a piece of land containing 280 sq. rds.? Ans.—$35.70.

If wheat for sowing contains $\frac{1}{20}$ weed seed, how much land will a farmer sow to weeds if he plants a 40-acre field? Ans.—2 acres.

What will be his loss if by sowing clean seed wheat his field would have yielded 25 bu. an acre worth 75 cts. a bu.? Ans.—$37.50.

If 25 bu. of 85-cent wheat can be grown on an acre, how many pounds is that per acre and what is the price per pound? Ans.—1500 lbs.; 1¼ cts.

BIRDS AND INSECTS

If the damage done by insects on a farm averages 60 cts. an acre for the entire farm, what would this amount to on a 240-acre farm? Ans.—$144.

Winter birds live on weed seed. If each bird eats a quarter of an ounce of weed seed in a day and there is a bird to each acre, how many pounds of weed seed will the birds eat on 320 acres in 3 months? Ans.—450 lbs.

Wild birds average about 400 to a quarter section of 160 acres. How many would this be for a township 6 miles square (36 sections)? Ans.—57,600 birds.

It is estimated that 500 small grasshoppers will eat a pound of a growing crop in one day. If a meadow lark eats 250 grasshoppers in a day, how many larks can save a ton of a growing crop in 10 days? Ans.—40 larks.

A stalk of plantain bears an ounce of seed or about 14,000 seeds. If 40 seeds sow one square yard of ground, what part of an acre will one stalk of plantain sow? Ans.—$\frac{35}{3884}$ A.

If 4 lbs. in every bushel of a farmer's crop of oats is weed seed, what per cent of his crop of 2000 bu. is weeds? How many pounds of oats? Ans.—12½%; 46,000 lbs. oats.

If a farmer seeded 20 acres of land with grass seed containing 10% weed seed, how much land would he sow to weeds? Ans.—2 acres.

Twelve bu. of clover seed containing 4½ bu. of dead seed were bought at $3.75 a bu., what was the price paid for the live seed? Ans.—$6.

Twenty bushels of clover seed containing 1½ bu. of dead seed were bought for $6 a bu. What was the price paid for the live seed? Ans.—$6.49

COWS, MILK AND BUTTER

Four per cent milk means that each 100 lbs. of milk contains 4 lbs. of butter fat.

Process: 100 lbs. × .04 = 4 lbs.

How many lbs. of butter-fat in 4000 lbs. of milk that tests 5%? Ans.—200 lbs.

How much less is the butter-fat if the milk tests 3%? Ans.—80 lbs.

A cow gives on an average 18 lbs. of 4% milk per day for 300 days each year. What is her yearly butter-fat production? Ans.—216 lbs.

When a cow yields 20 lbs. of milk daily which tests 3.2% butter-fat, what quantity of butter-fat is produced in a month of 30 days? How much is it worth at 28 cents a lb.? Ans.—19.2 lbs.; $5.376.

A cow gives 5400 lbs. of milk in a year testing 3% fat. How much is it worth at 28 cts. a lb.? Ans.—$45.36.

If a cow gives 5400 lbs. of milk in a year testing 5% fat, how much is the butter-fat worth at 28 cents a lb.? Ans.—$75.60.

A dairyman owns a herd of 12 cows that average 24 lbs. of milk each day from each cow. How many lbs. of milk does he get in a month of 30 days? Ans.—8640 lbs.

If this milk tests 3.8% and butter-fat is worth 28 cts. a pound, what does he receive monthly from his herd? How much per head? Ans.—$85.36; $7.11 per head.

The average cow gives about 4000 lbs. of milk in a year testing about 3.8% fat. How many lbs. of butter-fat does she give? What is it worth at 30 cts. a lb.? Ans.—152 lbs.; $45.60

If every farmer fed and cared for his cows in the best possible manner, the average yield of dairy cows would be increased about 100 lbs. of butter-fat for each cow per year. If butter-fat is worth 30 cts. a lb., how much more income would a farmer receive from a herd of 10 cows with extra care? Ans.—$300.

From the following record find the monthly income from each cow, with butter-fat at 25 cts. a pound. Which is the best cow and which the poorest?

	Daily Yield of Milk	Fat Test
Brindle	32 lbs.	3.5%
Brownie	16 lbs.	4 %
Rose	28 lbs.	3.5%
Cherry	18 lbs.	3 %
Red	15 lbs.	3.2%
Daisy	26 lbs.	5.4%

Ans.—Daisy, $10.53; Brindle, $8.40; Rose, $7.35; Brownie, $4.80; Cherry, $4.05; Red, $3.60.

At the Chicago Dairy Show, November, 1913, the U. S. Government displayed a herd of cows whose feed was carefully weighed and whose milk was weighed and tested. Below is the week's record tested for butter-fat of 3 of the cows in that herd. The cows were said to have freshened about the same time.

	Lbs. of Milk in 7 days	Av. % of butter-fat	Cost of feed
Grade, or scrub cow	49.6	4.6%	$1.44
Guernsey	235	6.5%	1.78
Holstein	350	3.8%	1.94

Find the amount of butter-fat produced by each cow during that week. Ans.—Grade, 2.8 lbs.; Guernsey, 15.2 lbs.; Holstein, 13.3 lbs.

Find the week's income from each cow with butter-fat at 33 cts. a pound. Ans.—Grade, $0.93; Guernsey, $5.02; Holstein, $4.39.

Find the weekly profit or loss after charging each cow with her feed. Ans.—Grade, loss $0.69; Guernsey, profit, $3.26; Holstein, $2.44 profit.

A dairyman sent to market 200 lbs. of 25% cream. From what quantity of 5% milk was the cream taken? Ans.—1000 lbs.

His neighbor sends with him 200 lbs. of 20% cream which was taken from 1000 lbs. of milk. What was the per cent of fat in this milk? Ans.—4%.

The temperature of cream ready for churning may vary from 50 degrees Fahr. to 66 degrees. As the temperature increases above 66 degrees Fahr. more butter-fat is left in the milk. The butter is also soft and of an inferior quality. This cream churns more slowly than thick cream. Churning should be stopped when the granules are about the size of a grain of wheat of large size.

Buttermilk churned from cream at a temperature of from 50 degrees to 60 degrees contains .2% of fat, when churned at a temperature of from 75 degrees to 80 degrees the buttermilk tests .9% butter-fat. What would be saved by churning at the lower temperature from a herd of cows from which 16,400 lbs. are annually produced? Ans.—114.8 lbs.

From the following record find the monthly income from each cow, with butter-fat at 25 cts. a pound. Which is the best cow and which the poorest? Arrange them in the order of the money income they produce.

A certain farmer has 15 good butter cows. The average per cent of butter-fat for the entire herd is 5.5%. If they yield 240 lbs. of milk on an average daily, what is the average daily production of butter-fat in pounds. Ans.—13.2 lbs.

What is the daily income from such a herd when butter-fat sells for 28 cts. a pound? Ans.—$3.70.

A certain farmer owned a Holstein cow that was very valuable but he did not know it because he had never tested her milk. He traded her for a scrub cow and $15. The Holstein was tested and found to give 800 lbs. of butter-fat in a year and the scrub, 125 lbs. What did the farmer lose in 5 years with butter-fat at 25 cts. a pound if both cows consumed the same amount of feed? Ans.—$843.75.

A farmer with a herd of Jersey cows numbering 10 had the week's weight of milk as follows: 210 lbs., 220 lbs., 212 lbs., 214 lbs., 204 lbs., 216 lbs., and 214 lbs. for each day. It tested 6% butter-fat which sold at 28 cts. a pound. How much did the cows average per head for the week? Ans—$2.50.

A dairyman hauls 24,650 lbs. of milk that tests 3.8% to a creamery. The price of butter-fat is 30 cts. a pound; how much money should he receive? Ans.—$281.01.

POTATOES

A bushel of potatoes weighs 60 lbs.

If an acre of potatoes yields 110 bu. what is the value of the crop at 40 cts. a bu.? Ans.—$44.

How many pounds of potatoes are grown on 2½ acres yielding 150 bu. per acre? Ans.—22,500 lbs.

If a potato farmer gave his crop careful attention it would cost him $25 an acre to grow potatoes. What is the net profit an acre if the yield is 110 bu. worth 40 cts. a bu.? If the yield is 250 bu. worth 40 cts a bu.—Ans. $19.; $75.

How many acres of potatoes producing 90 bu. an acre must he grow to return as much net profit as 10 acres yielding 180 bu. an acre if the cost and price are the same as in the above problem? Ans.—42.7 A.

Five farmers sell a carload of 650 bu. of mixed potatoes at 42 cts. a bu. They divide equally. How much does each receive? Ans.—$54.40.

Five other farmers sell a carload of 650 bu. of uniform potatoes at 52 cts. a bu. Divide the returns among them equally. Ans.—$67.60.

Jack Smith and his brother Jim belong to a potato club. Jack spends an extra day selecting his seed from the field as they are dug for his acre of potatoes. Jim takes his seed at random and his crop yielded 98 bu. an acre while Jack's yielded 140 bu. an acre. How much did Jack make the day he selected his seed potatoes if potatoes are worth 50 cts. a bu.? Ans. $21.

The next season Jack not only chose his seed from the field as the potatoes were dug but noticing some scabby potatoes he bought a pint of formalin for 50 cts. which he mixed with 35 gals. of water. Just before cutting the potatoes for planting he soaked them in this solution for 2 hours and killed the scab. Jack raised 200 bu. an acre which he sold for 55 cents a bu. Jim raised 110 bu. which on account of scab sold for 40 cts. a bu. Find Jack's profits over Jim's. Ans.—$66.

F. E. Bugbee of Hastings, Fla., reports as follows on untiled land: Cost of raising crop $88.50 an acre, gross income $130 an acre. Find the net income on 12½ acres. Ans.—$518.75.

Mr. Bugbee tile-drained a part of his land at a cost of $30 an acre. On this land the cost of raising a crop was $147.50 an acre and the gross income was $390 an acre. How many times did his clear profit on one acre pay for the tiling? Ans.—8 times.

In the Twin Falls country of Idaho the yield of potatoes is from 100 to 700 bu. per acre. The cost of producing a 150-bu. crop there is estimated at $44 an acre. At that rate what is the profit on 10 acres when potatoes sell at 50 cts. a bu.? Ans.—$310.

If by increasing the expense of the crop to $95 an acre a 600-bu. crop may be raised, what would be the net profit on 10 acres at 50 cents a bu.? Ans.—$2050.

POULTRY

If a flock of 80 hens average 90 eggs a year, what is the income from the flock with eggs at 20 cts. a dozen? Ans.—$120.

How many bushels of corn will it buy at 45 cts. a bu.? Of wheat at 70 cts.? Ans.—Corn, 266⅔ bu.; wheat, 171⅜ bu.

A flock of 200 hens average 90 eggs a year apiece. If the average price of eggs for the year is 20 cts. a dozen, what is the value of the flock's output? Ans.—$300.

If it takes 24 bu. of corn at 50 cts. a bu., 10 bu. of oats at 30 cts., and $15 worth of other feed to keep this flock for one year, what is the profit over the cost of the feed? Ans.—$270.

At 18 cts. a pound, what would be received from 60 hens weighing 7.5 lbs. each? Ans.—$81.

The market price of hens was 18 cts. a pound. What would be received from 60 hens each weighing 4.5 lbs. if the dealer docked them one cent a pound from the regular price because they were small and thin? Ans.—$45.90.

A farming community markets all their eggs together. If each farm produces 30 eggs a day how many farms will be needed to fill 7 cases each holding 30 dozen once a week? Ans.—12 farms.

What would be the gain per day on each farm if 5 cts. extra a doz. were secured by keeping the eggs clean and packing them neatly if it took a boy one hour each day whose services were worth 10 cts. an hour? Ans.—$1.40.

If a farmer's wife keeps 80 hens and each hen lays 125 eggs in a year, how much will her annual income be with eggs at 21 cts. a doz.? Ans.—$175.

If 12,000 lbs. of grain costing 1 cent a pound is required to feed the above flock a year and raise 300 young chickens, what will be her gain if the chicks are worth 35 cts. each and the eggs 21 cts. a dozen? Ans.—$160.

PROBLEMS WITH THE LEVER

The teeter-board is a kind of lever. The point of support is called the fulcrum. The teeter-board will balance when the weight on one end multiplied by its distance from the fulcrum equals the product of the weight on the other by its distance from the fulcrum.

John, who weighs 75 lbs., sits on one end of the teeter 6 ft. from the fulcrum, where must his brother Oscar sit if he weighs 60 lbs., to make the teeter-board balance?

Process: $75 \times 6 = 450$
$450 \div 60 = 7\frac{1}{2}$.—**Oscar sits $7\frac{1}{2}$ ft. from fulcrum.**

Cyrus, who weighs 120 lbs., sits on one end of a teeter 6 ft. from the fulcrum, how far from the fulcrum on the other end must his sister sit who weighs 90 lbs.? Ans.—8 ft.

John weighs 90 lbs., and his sister Jane 45 lbs. Both sit on one end of a teeter 8 ft. from the fulcrum. Victor weighs 120 lbs. How far from the fulcrum on the other end must he sit to balance John and Jane? Ans.—9 ft.

A man with a crowbar 6 ft. long places one end of it under a stone. He places the fulcrum, or rest, 1 ft. from the stone. If the man weighs 160 lbs., how heavy a stone can he raise with the crowbar? Ans.—800 lbs.

A man weighing 150 lbs. has a piece of timber 20 ft. long with which he wishes to raise the corner of a building. He places a fulcrum 6 in. from the building, how many pounds can he raise? Ans.—5850 lbs.

A doubletree is made for 2 horses of different weight. One end is 18 in. long and the horse pulls upon it with a force of 150 lbs. The other end of the doubletree is 20 in. long, how many pounds must that horse pull to keep even with the first? Ans.—135 lbs.

A doubletree is 4 ft. long. At what point must it be attached to a plow so that one horse will pull twice as much as the other? Ans.—16 in.; 32 in.

(NOTE.—What fraction of the load will each horse pull?)

At what point must the same doubletree be attached so that one horse will pull $1\frac{1}{4}$ times as much as the other? Ans.—$21\frac{1}{3}$ in.; $26\frac{2}{3}$ in.

(NOTE.—What fraction of the entire load does each horse pull?)

Two horses weigh 1600 lbs. and 1200 lbs. respectively. If each pulls $\frac{1}{10}$ of his own weight, how should a 4-ft. doubletree be attached so they will pull evenly? Ans.—$27\frac{3}{7}$ in. for the light horse; $20\frac{4}{7}$ in. for the heavy horse.

(NOTE.—Find what fraction of the load each horse pulls.)

ANIMAL POWER

The word "work" is used with different meanings. Men of science use it to mean motion against resistance. In this sense work is measured in foot-pounds. A boy pulling with a force of 2 pounds moves his little wagon 10 feet. The work done is 20 foot-pounds.

Process: $2 \times 10 = 20$ foot-pounds.

A man pushes a wheelbarrow with a force of 20 pounds long enough to move it 30 feet. The work done is 600 foot-pounds.

Process: $20 \times 30 = 600$ foot-pounds.

A horse pulling with a force of 150 pounds draws a load 10 rods. The work done is 24,750 foot-pounds.

Process: 10 rods = 165 feet.

$150 \times 165 = 24{,}750$ foot-pounds.

Rule.—Multiply the force in pounds by the distance in feet. The result is foot-pounds.

How much work is done when a 100-lb. boy climbs to the top of a 40-ft. windmill? Ans.—4000 foot-pounds.

How much work is done when a 60-lb. boy climbs a 9-ft. stairway? Ans.—540 foot-pounds.

How much work does a 1200-lb. horse do in walking up a 150-ft. hill? Ans.—18,000 foot-pounds.

(NOTE.—The force necessary to pull an object or tool is called the draft.)

The draft of a certain hand cart is 18 lbs. How much work does a man do in pushing it a mile? (5280 ft. in a mile.) Ans.—95,040 ft.-lbs.

How much work is done by a team in plowing a furrow 40 rods long when the draft of the plow is 450 lbs.? Ans.—297,000 ft.-lbs.

A horse does 290,400 ft.-lbs. of work in drawing a certain wagon one-half mile. What is the draft? Ans.—110 lbs.

What power is necessary to raise grain in an elevator to a height of 50 ft. at the rate of 990 bu. an hour? Ans.—49,500 ft.-lbs.

(NOTE.—There is always some power lost by contact of surfaces or friction.

In the foregoing problem what power will be required if 50% of it is lost in friction. Ans.—99,000 ft.-lbs.

If there could be such a thing as an absolutely smooth or frictionless horizontal surface a load moving along it would never stop, or in other words it would require no force to keep it going. But as there is always friction in some degree enough force must be used to overcome it if the load is to be kept in motion. By the use of wheels, lubricating oils, and hard road-beds, friction may be greatly reduced. The total force necessary to keep a ton moving on the best level macadam road may be as low as 30 to 50 lbs. On a hard, level earth road with an ordinary wagon the draft or traction is about 150 lbs. to the ton. A large draft horse may easily exert a force of 150 lbs. and keep this up working 10 hours a day walking at the rate of 2.5 miles per hour. This amount of work, 33,000 foot-pounds per minute, is called a horsepower.

If a horse is walking 2.5 miles an hour and pulling 150 lbs. on his traces, how much power is he developing? Ans.—1 horsepower.

Process: $\dfrac{150 \times 5280 \times 2.5}{60} = 33{,}000$ ft.-lbs. a min. or 1 horsepower.

A horse is walking 2.5 miles per hour and pulling 100 lbs. on his traces. How much power is he developing? Ans.—$\frac{2}{3}$ horsepower.

Process: $\dfrac{100 \times 5280 \times 2.5}{33000 \times 60} = \frac{2}{3}$ horsepower.

(NOTE.—Use cancellation.)

How many horsepower is a horse developing when walking 5 miles an hour and pulling 60 lbs. on his traces? Ans.—$\frac{1}{8}$ horsepower.

How many horsepower is a team developing when walking 4 miles an hour and steadily pulling 165 lbs.? Ans.—1.7 horsepower.

If it requires a 1500-lb. draft horse walking at the rate of 2.5 mi. an hour to develop 1 horsepower, how much power may be exerted by a 1000-lb. horse walking at the same rate? Ans.—$\frac{2}{3}$ horsepower.

Careful tests have been made showing that a horse may be expected to pull about $\frac{1}{10}$ of its own weight and keep it up 10 hours a day walking 2.5 miles an hour. This pulling power is called traction.

If a horse can pull steadily with a force equal to $\frac{1}{10}$ of its own weight, what draft will a 1200-lb. horse exert? Ans.—120 lbs.

How much power will he develop walking 2.5 mi. an hour? Ans.—$\frac{8}{10}$ horsepower.

How much power may be expected from a 1500-lb. horse walking at the same rate? Ans.—1 horsepower.

At the same rate how much power may be expected from an 1800-lb. horse? Ans.—$1\frac{1}{5}$ horsepower.

What should be the pulling power of a two-horse team, one weighing 1600 lbs. and the other 1200 lbs. walking at the rate of 2.5 mi. per hour for 10 hours a day? Ans.—280 lbs.

How much horsepower is this team developing? Ans.—1.8 (plus) horsepower.

What should be the pulling power of a two-horse team, one weighing 1500 lbs. and the other 1400 lbs., walking at the rate of 2.5 mi. an hour for 10 hours? Ans.—$1\frac{1}{2}\frac{4}{5}$ horsepower.

If a horse pulls $\frac{1}{10}$ of its own weight steadily for 10 hours a day walking 2.5 mi. an hour, how does a team of draft horses weighing 3200 lbs. compare with a light team, weighing 1800 lbs.; in horsepower? Ans.—$2\frac{2}{5}$ h. p.; $1\frac{1}{5}$ h. p.

COUNTING

12 things are one dozen (doz.).
12 dozen are 1 gross (gro.).
12 gross are 1 great gross (G. gro.).
20 things are 1 score.
24 sheets of paper are 1 quire.
20 quires or 480 sheets are 1 ream.

TIME MEASURE

60 seconds (sec.) are 1 minute (min.).
60 minutes are 1 hour (hr.).
24 hours are 1 day (da.).
7 days are 1 week (wk.).
2 weeks are 1 fortnight.
30 das. (31, 28, 29 das.) are 1 month (mo.).
3 months or 13 weeks are 1 quarter.
12 months or 365 days are 1 common year (yr.)
366 days are 1 leap year.
10 years are 1 decade.
100 years are one century (C.).

WEIGHTS OF PRODUCE IN A BUSHEL

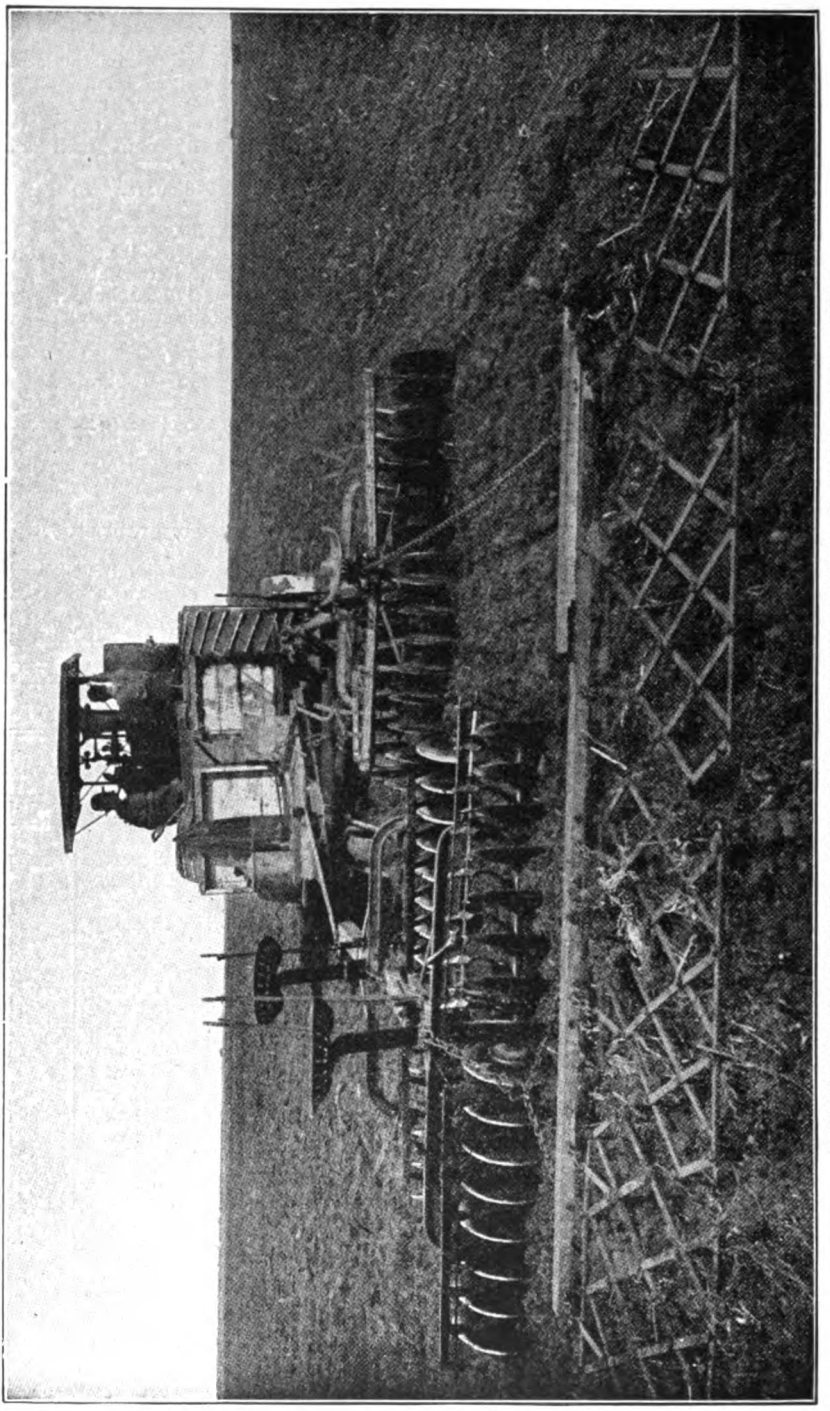
Wheat.....60 lbs.
Corn in the ear.....70 lbs., except in Miss., 72 lbs. in Ohio, 68 lbs. in Ind. after Dec. 1, and in Ky. after May 1 following the time of husking, it is 68 lbs.
Corn shelled.....56 lbs., except in Cal., 54 lbs.
Rye.....56 lbs., except in Cal., 54 lbs.; in La. 32 lbs.
Buckwheat.....48 lbs., except in Cal., 40 lbs; Ky., 56 lbs.; Ida., N. D., Okl., Ore., S. D., Tex., Wash., 42 lbs.; Kan., Minn., N. C., N. J., Ohio., Tenn., 50 lbs.
Barley.....48 lbs., except in Ore., 46 lbs.; Ala., Ga., Ky., Pa., 47 lbs.; Cal., 50 lbs; La., 32 lbs.
Oats.....32 lbs., except in Ida. and Ore., 36 lbs.; in Md., 26 lbs.; in N. J. and Va., 30 lbs.
Peas.....60 lbs.
White beans.....60 lbs.
White potatoes.....60 lbs., except in Md., Pa., Va., 56 lbs.
Sweet potatoes.....55 lbs.
Onions.....57 lbs.
Turnips.....55 lbs.
Dried peaches.....33 lbs.
Dried apples.....26 lbs.
Clover seed.....60 lbs., except in N. J., 64 lbs.
Flax seed.....56 lbs.
Millet seed.....50 lbs.
Hungarian grass seed 50 lbs.
Timothy seed.....45 lbs., except in Ark., 60 lbs.; N. D., 42 lbs.
Blue grass seed.....44 lbs.
Hemp seed.....44 lbs.
Corn meal.....50 lbs., except in Ala., Ark., Ga., Ill., Miss., N. C., Tenn., 48 lbs.
Bran.....20 lbs.

HANDY VALUES

1 bu. = 2150.4 cu. in.
1 bu. = 1¼ cu. ft. (approximately), used for wheat, shelled corn and all small grains.
1 bu. corn on cob = 2½ cu. ft.
1 bu. corn in husk = 3¼ cu. ft.
1 heaped bu. = 2747.7 cu. in. (used for apples, potatoes, turnips).
1 heaped bu. = 1 5/9 cu. ft.
1 gal. = 231 cu. in.
1 gal. water = 8¼ lbs.
1 gal. average milk = 8½ lbs.
Milk averages 3.8% butter-fat.
1 lb. butter-fat = 1 1/6 lbs. butter.
1 bbl. = 4 cu. ft. (approximately).
1 bbl. = 31½ gals.
1 bbl. cement = 4 cu. ft.
1 bag or sack cement = ¼ bbl.
1 ton of well-packed timothy = 512 cu. ft.
1 ton of well-packed clover = 450 cu. ft.
1 cu. ft. water = 62½ lbs.
1 cu. ft. of ensilage = 30 lbs. (in small silo).
1 cu. ft. of ensilage = usual daily ration for a cow.
1 cu. ft. = 7½ gals. (approximately).
1 cord = 128 cu. ft.
1 ear of seed corn has about 800 kernels.
Corn shrinks 10% or more the first 6 months after husking.
1 roll of barbed wire weighs 100 lbs. approximately.
1 roll of barbed wire = 1200 ft. approximately.
1 mile = 5280 ft.

Grains and Vegetables	Average Quantity of Seed per Acre for Planting	Legal Weight per Bushel
Alfalfa	30 lbs.	60 lbs.
Barley	8 pks.	48 lbs.
Blue grass	20 lbs.	14 lbs.
Buckwheat	4 pks.	48 lbs.
Clover	12 lbs.	60 lbs.
Corn (in the husk)	.....	72 lbs.
Corn, shelled, check row	7 qts.	56 lbs.
Corn, on cob	.....	70 lbs.
Corn, ensilage	10 qts.	.....
Cotton, upland	6 pks.	32 lbs.
Cowpea	6 pks.	60 lbs.
Oats	2½ bu.	32 lbs.
Potato	10 bu.	60 lbs.
Rye	6 pks.	56 lbs.
Timothy	15 lbs.	45 lbs.
Wheat	8 pks.	60 lbs.
Sweet potatoes	.....	55 lbs.
Beans	.....	60 lbs.
Peas	.....	60 lbs.
Corn meal	.....	48 lbs.
Bran	.....	20 lbs.

(Legal weights vary in different states. See above. Extra fine wheat may weigh as much as 65 lbs. per bu Oats sometimes weigh 40 lbs per bushel.)



A PRIMITIVE INDUSTRY REVOLUTIONIZED BY MODERN POWER—PLOWING BY MACHINERY

FARM SCIENCE AND PRACTICE

There is widespread and growing demand for practical knowledge concerning scientific agriculture and country life. No subject now taught in the schools can be eliminated without serious objection, nor does there seem to be room for others to be crowded in. New subjects of agriculture and country life, therefore, must be acquired largely through the old subjects, re-cast and re-directed along agricultural lines so that the child in the country or in suburban districts may be taught in terms of his own environment. This is particularly true of the rural science and other practical subjects, a knowledge of which is in daily demand.

No subject is so well adapted to make clear the results of the best agricultural practices as arithmetic. It may be used to drive home the correct principles of farming and to nail them fast with figures. Moreover, no subject is more popular with boys and girls than arithmetic. It is, therefore, the best of all mediums through which to introduce scientific agriculture.

CHOOSING A FARM

WHAT *are the two points to consider in buying a farm?*

The economic, or money-making value, and the home value.

What is the home value?

A healthful location, near to schools, churches and desirable neighbors.

Which should be considered first, the home or economic value?

It depends whether one is to live on the farm or not.

Should a farmer invest all his capital in land?

It may be safe in a pioneer country where values are bound to rise but in older communities the higher the price of land the lesser part of one's capital should be invested in the bare land.

When should a farmer locate near a market?

If he intends producing cream, milk, fruit or even grain.

When can he afford to locate farther from a market or shipping point?

If he is a stock raiser, because they can be driven some distance.

Is it worth while to pay more for a farm near a transcontinental railroad?

Yes. It costs more to ship when two roads must be used to reach a large city market.

How far may milk and grain be hauled to market with profit?

Three miles is as far as a farmer can profitably haul his own milk, while five miles is a long haul for grains. Ten miles is not too far to market stock.

What relation do wagon roads bear to farming?

A farmer may travel two miles over a hard road with easy grades more easily and quickly than over one mile of hilly or muddy roads.

What other things should be considered in locating?

Electric lines add greatly to the value of a farm, also telephone lines. The occupation of the other farmers may help to advertise a section for fruit or fine stock and thus bring buyers that way.

For an investment which is better—a farm with no improvements or one with extensive improvements?

Better than either is a farm with moderate improvements just sufficient for the conduct of the farm.

What practice of farmers has contributed most toward exhausting the soil?

Raising the same crop on a given field for forty or fifty years without fertilizing or manuring or rotating.

ROTATION OF CROPS

Why should not the same crop be grown continuously on the same soil?

It will tend to exhaust certain plant foods needed by the crop because some crops make a special drain on one element of food.

How do plants differ in their manner of root growth?

Some plants, like wheat, are shallow-rooted and are surface feeders, while others extend their roots deeper.

Why is it wise to rotate deep and shallow rooted crops?

Because they feed at different depths and this plan will not exhaust the soil so quickly.

What other reason for this method?

The deep-rooted crops probably leave near the surface some food procured deeper in the soil.

What is the effect of shallow-rooted crops following deep-rooted crops?

They always prosper.

How does rotation affect the physical condition of the soil?

Different crops receive different cultivation and the shortcomings of one crop treatment is corrected by the preparation for the next crop and thus the soil is kept in better condition.

Does the different manner of rooting affect the soil?

It is well to have the roots of stubble, clover and grasses periodically left in the soil to decay to improve the texture of the soil.

What effect has rotation on the farmer's labor?

Rotation distributes the care of crops throughout the season and thus economizes labor, and enables the farmer to keep regular help which is better than transient help.

Does rotation affect plant diseases?

Most plant diseases are fungi or bacteria that live in only one kind of plant. Therefore rotation starves them out.

What effect has rotation on insects?

Most insects have their favorite crops and as many of them live only a few years they, too, are starved out by rotation.

How does rotation affect weeds?

Crops are cultivated differently and harvested in different manners and at different times and this tends to drive out weeds by striking them at their weak points.

If land is badly infested with a certain weed how can it be freed from it?

By leaving out of the rotation the particular crop whose cultivation offers aid to the weed.

What effect has rotation on the size of the crop?

Experiments show much better crop yields where rotation is practiced.

Can any general rules be given for rotation?

Every rotation should include at least one hoed or cultivated crop such as corn and potatoes and one legume such as clover.

Why is the hoed crop desirable?

It destroys weeds and improves tilth.

Why the leguminous crop?

Because legumes are deep-rooted and get food from the subsoil; they increase the nitrogen supply in the soil and leave it porous.

Give a general rule for rotation.

The crops should vary as much as possible in food requirements, manner of growth, root system, and in the season during which they occupy the ground.

PRESERVING FOODS

What causes canned goods to spoil?

The presence of any one of three living organisms will cause decay of vegetable or animal matter—they are yeast, molds, and bacteria.

What conditions aid the growth of yeast plants?

They need warmth, moisture, sugar.

How does the yeast plant grow?

By budding, that is, the parent

plant divides into two plants and these grow and divide, and the process continues as long as conditions are favorable.

Where will yeast grow most easily?

In fruit juice and slightly sweetened fruit, but not in thick sirups or preserves. It is easily killed by a high or low temperature.

How does mold get a start?

The spores or seeds of mold are very light and may be floating in the air. When they lodge on a warm, moist surface such as food often presents, they germinate and cover the surface.

How may molds be destroyed?

By exposure to a high temperature for about twenty minutes.

Where do bacteria grow?

Bacteria multiply rapidly in meat, milk, and legumes, but will not grow in thick sirups or acids.

What makes fruit juices form jelly?

A carbohydrate resembling starch called pectin is an important factor in the juice of ripe or nearly ripe fruit. When equal amounts of sugar and fruit juice are mixed and heated this pectin causes the mixture to gelatinize or form jelly.

What are the essentials in canning and preserving?

Cleanliness and sterilization.

How shall we sterilize?

By scalding or boiling all kettles, jars, strainers, rubbers and other utensils used in canning.

Give general rules for canning foods.

Kill all germs in the food and inside the cans and seal while hot so as to prevent other germs from the air to enter.

How does the drying of fruits and meats preserve them?

Germs or bacteria cannot grow without the presence of water.

Why does salting meat preserve it?

Because bacteria cannot live in a strong solution of common salt.

Does putting fruit and meat in cold storage kill the bacteria?

A low temperature simply keeps them from growing and multiplying. They begin to act as soon as the temperature rises.

How does smoking meat preserve it?

Smoking coats the outside of the meat with a thin layer of creosote which not only kills all germs present but gives the meat a different flavor.

What effect has sugar on keeping qualities?

Sugar is a preservative against the action of germs. It is used in curing meats and extensively in preserving fruit.

Why does preserving keep fruit?

"Boiling down" for a long time kills the germs and drives off the water, making conditions unfavorable to growth.

What makes milk sour?

Germs or bacteria.

Where do they come from?

The air is full of germs, the dust from the barn is laden with them and they are on the milk pail and the hands of the milker.

How should we care for milk cans and pails?

They should all be thoroughly washed and scalded and placed in the sunlight which is an enemy to germs.

What causes butter to become rancid and how prevented?

Bacteria. It is best overcome by working out all the water which bacteria need and mixing in salt.

What makes cider turn to vinegar?

The solid slimy mass known as mother of vinegar is a vast colony of bacteria. It is the action of these that causes the change.

Where do the vinegar-making bacteria come from?

From the air and from the barrel. The process may be hastened by introducing "mother of vinegar."

PLANT LIFE IN THE GARDEN, ORCHARD, VINEYARD AND GREENHOUSE

What are the parts of a plant?

There are five: root, stem, leaf, flower and seed.

What are the uses of the root?

The roots hold the plant in place and prevent its blowing away, they take nourishment and moisture from the soil; and serve as storage places for plant food.

What is a root cap?

The tip of the tender root has a little cap on the end to enable it to force its way among the soil particles without injury.

What are root hairs?

They are a hair-like, velvety growth covering the real roots.

What is the use of root hairs?

The root hairs present a much greater surface through which the plant may absorb food and moisture.

Do the real or fibrous roots absorb food and moisture?

No, this is the work of the root hairs, which cover the fibrous roots.

How do the root hairs take their food?

Their walls are very thin and the plant food in order to enter must be in a soluble or watery form which will pass through these thin walls.

What is this passing of liquids through the thin partitions of the membranes called?

It is called *osmosis*. It is the same process as that by which the food passes from the alimentary canal of animals into the blood.

What are the uses of plant stems?

They support the leaves and hold them up in the air and sunlight. They serve as storehouses for starch and sugar and other forms of plant food for the future use of plants. The stems are also channels for the passage of sap through the plant.

What is the use of the sap?

It carries raw plant food from roots to leaves and then carries the manufactured food like starch and sugar tc the place where it is needed to build up the plant or to the place of storage.

What uses have leaves?

The leaves give off water to the air, take carbon from the air, and change raw plant food to starch and sugar. They are the food factory of the plant.

In what form does carbon exist in the air?

The air contains carbonic acid gas which is composed of oxygen and carbon. It is sometimes called carbon dioxide.

From what does the air obtain carbonic acid gas?

It is exhaled or breathed off by all animal life. It is also given off by decaying plant life.

How does the leaf get hold of carbonic-acid gas?

The air may enter the leaf through openings on the under side called *stomata* which means "mouths."

How does the leaf separate the carbonic-acid gas into oxygen and carbon?

The heat furnished by sunlight and the green coloring matter of leaves called chlorophyll act together and separate the oxygen from the carbon.

What becomes of the oxygen? and carbon?

The oxygen is given off to the air and the carbon is combined with other food elements to make such compounds as starch and sugar which are then ready to build up the plant.

What is the use of chlorophyll?

Only the plants that have the green chlorophyll are able to use carbon dioxide from the air to manufacture starch and sugar.

What about the plants that grow in the dark?

Mushrooms grow in dark places and can get no food from the air because they have no green chlorophyll. Their food comes from partly decomposed matter in the soil.

What is meant by the balance in nature?

Animals need large quantities of oxygen which plants give off while plants need large amounts of carbon dioxide which animals give off. What is poison or waste of animals is food for plants, and the reverse is also true.

What things besides plant food are needed for plants?

Plants need light, heat, moisture, and air.

What is the main aim of life for all plants?

To produce seed.

What part of the plant bears the seed?

The flower.

What parts has a perfect flower?

Pistils and stamens.

What is the office of the stamens?

Stamens are the male part of the flower. They bear the yellow dust or pollen which is needed to fertilize the pistil or female part to enable it to produce seed.

What are imperfect flowers?

When the flowers of a plant do not contain both male and female parts they are known as imperfect flowers.

How do imperfect flowers bear seed?

The pollen must be carried to the flowers having the pistils by some means.

How is it carried?

The pollen of corn, which is light, is carried by the wind. In some cases it is carried by insects, such as bees.

What is cross-pollination?

Plants are cross-pollinated when the pollen is taken from one to another by some means. Some varieties of apples, pears, peaches and plums will not bear fruit if grown by themselves, but will bear abundantly if pollinated by other varieties that blossom at the same time.

Describe a seed.

A seed bears within its coat a minute plant called a germ.

What is the purpose of this germ or tiny plant?

To develop into a new plant like the parent when proper conditions are offered.

How can the seeds begin to grow with no leaves in the air and no roots in the ground?

Some nourishment prepared by the parent plant is stored up in the seed to feed it until it can put forth leaves and roots of its own.

Where is this store of nourishment?

In the bean it is in the two seed leaves. In the corn kernel a store of starch is found about the germ.

What part of the stem carries the water from the roots to the leaves?

In plants with netted veins in the leaves the water passes up mainly through the ducts or channels in the outer wood.

How are plants classified?

They may be classified in different ways. According to length of life as annuals, biennials, and perennials.

What are annuals?

Annuals are plants that live only one year from the planting of the seed to the production of the new seed, such as oats, peas, beans and tomatoes.

What are biennials?

Biennials live two years from seed to seed, such as cabbages, parsnips and common mullein.

What are perennials?

Perennials live more than two years, such as asparagus, alfalfa, strawberries and trees.

How do we know that different plants take different amounts of plant foods from the soil?

Chemists have analyzed various plants and thus ascertained what elements they contain and in what proportion.

How many elements in the soil?

Between seventy and eighty are known.

Why are they called elements?

Because scientists have not been able to separate them into similar substances.

Are most materials that we know simple elements?

Most materials are compounds, that is, they are combinations of two or more elements combined in different proportions.

What are some compounds that make different articles because the proportion of their elements differ?

Alcohol, sugar, starch, and fats all contain the same elements, carbon, hydrogen, and oxygen, but in different proportions.

Are there many compounds in a single plant?

Yes, but they may be separated and known.

What proportion of corn plant is water?

One thousand pounds of mature corn contains nearly 800 pounds water, 12.7 pounds hydrogen, and 88.9 pounds oxygen, and since both hydrogen and oxygen come from water nearly 900 pounds of the 1000, or nine-tenths of the corn plant, is water.

Is this nine-tenths of the plant's weight all the water it needs to grow?

It is only a small part, for the leaves are constantly giving off moisture to the air, and it is from this moisture that the plant obtains mineral foods.

How many pounds of water does the plant use for every pound of dry matter?

About 300 pounds of water passes through the plant for each pound of dry matter produced.

About how much water is needed by an acre of good corn during the growing period?

About 900 tons, an amount if spread over the acre would be nearly 8 inches deep.

Does this include the water lost from the land by drainage?

No, about as much water runs away and passes down beyond the reach of the roots of the corn as is used by the crop, so that about 1800 tons of water should fall upon an acre of growing corn.

How does the plant obtain moisture?

It all comes from the ground through the roots.

In what other way is water useful to plant life?

Besides furnishing about nine-tenths of the plant's weight, it dissolves other plant foods in the soil and puts them in shape to be taken up in a liquid form by the roots.

What makes a plant wilt on a very hot day?

Because the leaves are giving off moisture to the air faster than the roots can supply it to the plant.

Is there any other factor so important to plant life as proper moisture?

No. More soils fail to produce good crops for lack of proper moisture than for any other cause.

Do plants get any food from the air?

Nearly half of the dry matter in the plant consists of carbon, all of which comes from the air in the form of carbonic-acid gas.

Is carbonic-acid gas pure carbon?

It is a compound of carbon and oxygen, but the plants separate these elements, retain the carbon and set the oxygen free.

How is this done?

The green coloring matter of the leaves or the chlorophyll with the help of the heat energy furnished by the sunlight breaks apart the carbon and oxygen.

Is sunlight necessary to this process?

Plants grow more vigorously in full sunlight than in shade, and at night this growing process ceases.

Will not plants germinate in the dark?

They grow until they use up the food stored in the seed, but they have no power to use the food in the air and soil without chlorophyll and sunlight. Analysis shows that the plant grown in the dark contains less dry matter whan was present in the seed.

How does the plant use carbon?

It causes the carbon to combine with water and mineral matter which are taken through the roots, and these elements form carbohydrates of which the plant is composed.

Is it necessary for the farmer to buy carbon to fertilize his soil?

The atmosphere furnishes free an inexhaustible supply of carbon for all vegetation.

What is the most costly plant food?

Nitrogen.

Do plants contain a high percentage of nitrogen?

Nitrogen forms only from one to three per cent of the dry matter or about one-half of one per cent of the green plant. But a crop must have this proportion in order to thrive.

Where do plants get their supply of nitrogen?

From the soil only.

Where does the soil get nitrogen for the growing crops?

A small part comes directly from the atmosphere, brought by rain water. But most of the nitrogen is taken from the air and stored in the soil by bacteria that live in small swellings or nodules on the roots of certain plants called legumes, such as clover, alfalfa, soy bean, cowpea, and the like.

How can the farmer help these bacteria?

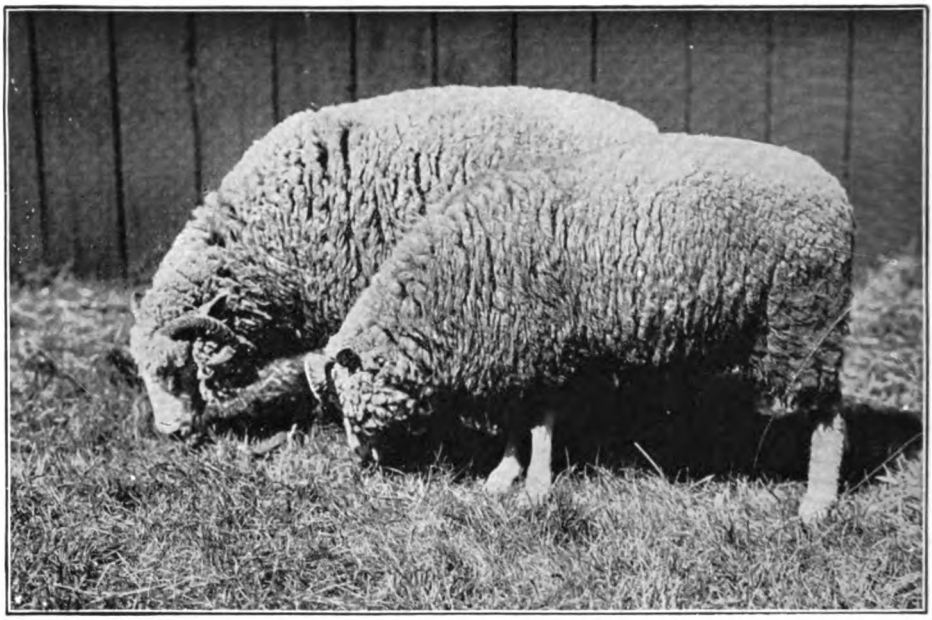
By stirring the soil so the air can enter it, for bacteria cannot live without oxygen from the air.

What part of the green plant comes from the air?

Including water, ninety-eight and one-half per cent comes from the air free of cost and the supply of these elements of food in the air is beyond control.

Are there many elements of food in the other one and one-half per cent of green plants?

There are about a dozen, but the three demanding the farmer's attention are nitrogen, phosphoric acid and potash. The other elements are generally found in the soil in abundance except occasionally lime is missing.



STOCK FEEDING

Foods may be said to serve two purposes. They either build up the body or furnish heat and energy. They are divided into three classes: proteins, carbohydrates, and fat.

Protein is a name given to a group of feeds or compounds from which animals make muscle or lean flesh, bone, hair or wool, tendons, nerve, casein, and albumen in milk, etc. Since no other compound can take the place of protein it is important that enough of this be fed or the animal cannot keep up in flesh and production or work. If too much protein is fed it will replace the other food elements, but as feeds containing a high percentage of protein are usually expensive it is unwise to feed more of it than is needed. Feeds containing a large proportion of protein, such as clover, bran, and oil meal, are called nitrogenous foods.

Carbohydrates (C. H.) are those compounds in feed that are composed of carbon, hydrogen and oxygen, but have no nitrogen. Sugar, starch, fiber and others are carbohydrates. They are used in the body to produce fat or are burned to produce heat or energy. They cannot take the place of protein.

Fat. The oils, wax and fats contained in feed are called fats. In the animal body they are used for the same purpose as are carbohydrates. One pound of fat is equal to 2¼ pounds of carbohydrates.

The work horse and cow of average size require daily about two pounds of protein and twelve pounds of carbohydrates.

If a farmer intends to feed his animals without waste he must give them protein and heat and fat producing elements (which latter includes C. H. and fats) in certain proportions. It may be 1 : 6 or 1 : 11 or some other proportion. This correct proportion is called a balanced ration which is indicated by figures called a nutritive ratio.

The following table gives the digestible protein and carbohydrates contained in certain feeds. The fats are included with the carbohydrates.

	Estimated Price	IN 100 LBS. OF FEED			
		Protein	Protein	Carbohydrates (Including Fats)	
		lbs.	per cent	lbs.	per cent
Corn fodder	$3 per T.	2.5	2.5%	37.3	37.3%
Timothy hay	$12 per T.	2.8	2.8%	46.6	46.6%
Clover hay	$12 per T.	6.8	6.8%	39.6	39.6%
Cowpea hay	$12 per T.	10.5	10.5%	40.	40%
Alfalfa hay	$12 per T.	11.	11%	42.4	42.4%
Oat straw		1.2	1.2%	40.4	40.4%
Wheat straw		.4	.4%	37.2	37.2%
Wheat bran	$18 per T.	12.2	12.2%	45.3	45.3%
Corn	49 cts. per bu.	7.9	7.9%	76.4	76.4%
Oats	37 cts. per bu.	9.2	9.2%	56.8	56.8%
Cotton seed meal	$30 per T.	37.2	37.2%	44.4	44.4%
Corn stover	$5 per T.	1.7	1.7%	34.	34%
Corn silage	$3 per T.	.9	.9%	12.9	12.9%
Skim milk	20 cts. per cwt.	2.9	2.9%	5.9	5.9%

DIGESTIBLE NUTRIENTS IN 100 POUNDS OF VARIOUS FEEDING STUFFS

	Total Dry Matter	POUNDS AND PER CENTS OF DIGESTIBLE NUTRIENTS				Nutritive Ratio
		Protein		C. H. and Fat ×2.25		
	lbs. or %	lbs.	%	lbs.	%	
Alfalfa hay	91.6	11.	11.	42.3	42.3	1: 3.8
Apples	19.0	.7	.7	18.8	18.8	1:26 8
Barley, grain	89.1	8.7	8.7	69.1	69.1	1: 7.9
Beet, mangel	9.1	1.1	1.1	5.6	5.6	1: 5.1
Cabbage	15.3	1.8	1.8	9.1	9.1	1: 5.1
Carrot	11.4	.8	.8	8.3	8.3	1:10.4
Clover, red (green)	29.2	2.9	2.9	16.4	16.4	1: 5.7
Clover, red (hay)	84.7	6.8	6.8	39.6	39.6	1: 5.8
Corn fodder, dry	57.8	2.5	2.5	37.3	37.3	1:14.9
Corn, grain	89.1	7.9	7.9	76.4	76.4	1: 9.7
Corn silage	20.9	.9	.9	12.9	12.9	1:14.3
Corn stover	59.5	1.7	1.7	34.0	34.	1:20
Cottonseed meal	91.8	37.2	37.2	44.4	44.4	1: 1.2
Cowpea hay	89.3	10.8	10.8	40.	40.	1: 3.9
Linseed meal	89.	28.2	28.2	47.	47.	
Meat scrap	89.3	66.2	66.2	31.1	31.1	1: 0.5
Milk, cows'	12.8	3.6	3.6	13.2	13.2	1: 3.7
Skim milk (separator)	9.4	2.9	2.9	5.9	5.9	1: 2.
Buttermilk	9.9	3.9	3.9	6.5	6.5	1: 1.7
Hay (mixed grasses)	87.1	5.9	5.9	43.6	43.6	1: 7.4
Oat straw	90.8	1.2	1.2	40.4	40.4	1:33.7
Oats, grain	89.	9.2	9.2	56.8	56.8	1: 6.2
Potatoes	21.1	.9	.9	16.5	16.5	1:18.3
Pumpkin, field	19.1	1.4	1.4	6.5	6.5	1: 4.6
Rye, grain	88.4	9.9	9.9	70.1	70.1	1: 7.1
Rye bran	88.4	11.5	11.5	54.8	54.8	1: 4.8
Rye straw	92.9	.6	.6	41.5	41.5	1:69.2
Soy-bean	89.2	29.6	29.6	54.7	54.7	1: 1 8
Timothy hay	86.8	2.8	2.8	46.6	46.6	1:16.6
Turnip, flat	9.5	1.0	1.0	7.7	7.7	1: 7.7
Wheat, grain	89.5	10.2	10.2	73.	73.	1: 7.2
Wheat bran	88.1	12.2	12.2	45.3	45.3	1: 3.7
Wheat middlings	87.9	12.8	12.8	60.7	60.7	1: 4.7
Wheat straw	90.4	.4	.4	37.2	37.2	1:93.

Some animals require one ratio and other animals a different ratio depending upon whether the animal is young and growing or mature, whether it is at work or at rest. Ratios are said to be wide or medium or narrow. Timothy hay (1 : 16.6) is wide; alfalfa (1 : 3.8) is a narrow ratio.

FINDING THE RATIO

The nutritive ratio is found by dividing the pounds of protein in a feed or ration, into the pounds of C. H. (including the fats). This may be more easily understood by putting these amounts in the form of a fraction, in which the protein is the numerator and the C. H. including fats is the denominator. Thus the nutritive ratio of

$$\text{Alfalfa} = \frac{11}{42.3}$$ (See table Page 257)

Divide both terms of the fraction by the numerator

$$\frac{11}{42.3} \div \frac{11}{11} = \frac{1}{3.8}$$

$\frac{1}{3.8}$ is the same as 1:3.8

FEEDING STANDARDS

Different animals require different quantities of feed and different nutritive ratios. A dairy cow producing milk must have a feed rich in protein, a dry cow does not require so much protein. A horse at heavy work requires a different feed from that of one at rest; a growing pig from a mature hog that is being fattened for market.

The following table shows the amounts of digestible nutrients per day in feeding standards upon the basis of 1000 pounds of live weight.

FEEDING RATIONS PER DAY FOR 1000 LBS. OF LIVE WEIGHT

	Dry Matter	DIGESTIBLE		Nutritive Ratio
		Protein	C. H. including Fats (×2¼)	
Oxen at rest in stall	18 lbs.	0.7 lbs.	8.2 lbs.	1:11.8
Growing pigs	36 lbs.	4.5 lbs.	26.6 lbs.	
Fattening swine	32 lbs.	4 lbs.	25.1 lbs.	
Growing calves	30 lbs.	2.5 lbs.	16.1 lbs.	
Fattening cattle	30 lbs.	3 lbs.	16.1 lbs.	
Horse (light work)	20 lbs.	1.5 lbs.	10.4 lbs.	
Horse (heavy work)	26 lbs.	2.5 lbs.	15.1 lbs.	
Dairy cow (giving 11 lbs. milk daily)	25 lbs.	1.6 lbs.	10.7 lbs.	
Dairy cow (giving 16.5 lbs. milk daily)	27 lbs.	2 lbs.	11.9 lbs.	
Dairy cow (giving 22 lbs. of milk daily)	29 lbs.	2.5 lbs.	14.1 lbs.	
Dairy cow (27.5 lbs.)	32 lbs.	3.3 lbs.	14.8 lbs.	
Wool sheep (coarse breed)	20 lbs.	1.2 lbs.	11 lbs.	
Wool sheep (fine breeds)	23 lbs.	1.5 lbs.	12.7 lbs.	

Bran alone does not make a balanced ration for a cow because if a sufficient amount of bran is fed to furnish two pounds of protein the cow does not get enough C. H. If enough is fed to furnish the correct amount of C. H., then she is given more protein than she can use, and it is wasted. Bran is not only too expensive but too concentrated and should be fed sparingly. Hay, fodder, silage and the like will give the proper bulk for a ration and furnish cheaper food.

Since protein is the element of food most commonly lacking in feed rations on the farm, every feeder should make sure that he is providing enough protein. The cheapest way to provide protein is to raise a legume such as clover, alfalfa, or cowpea hay which is very rich in protein.

If a farmer must buy protein it is best to estimate its cost according to the percentage as given on page 258 and the market price. In the foregoing problems it is figured on an average market price. It must be remembered that it does not cost a farmer $12 a ton to raise clover, cowpea, or alfalfa hay, but more nearly $4 a ton.

HEAT VALUE OF FATS

By careful test it has been shown that one pound of fat will produce 2¼ times as much heat or energy as one pound of carbohydrates.* In the table on page 258 the fats are included in the C. H. Many tables give them separately and the farmer or pupil should know how to deal with such tables.

DRY MATTER

The mature student will take note that the bulk of the ration—that is, the pounds of dry matter in each ration—has been omitted for the sake of making the problems simple. In compounding the ration the dry matter is important. The dry matter in each ration may easily be computed from the percentage given in column 1, page 258. The amount of dry matter may vary two or three pounds from the exact amounts called for on page 258 without much consequence.

MIXING A RATION

It is not necessary to weigh a ration each day. Mix the grain ration in proper proportions and use a measure that contains the right amount for each animal. Weigh the hay once or twice and thereafter it can be estimated with sufficient accuracy.

Each pupil should try to make a ration for a 1000-pound cow giving 16½ pounds milk, using such feeds as are commonly used on your farm. You will have to make several trials perhaps before you get the right amounts. Remember that if your ratio is too wide it needs more protein and therefore use more clover, alfalfa or cowpea hay or if your feed is already too bulky, that is, if it already has too much dry matter, then use bran or linseed meal or cottonseed meal, or some concentrated food to reduce the ratio to suit your animal. The dry matter should be within a few pounds of the amount required in table, page 258. The amount of dry matter is found by using the percentages given in column 1, page 258.

FERTILIZERS

James J. Hill tested 151 farms in the northwest for wheat, barley and oats. By applying 8.9 pounds of nitrogen, 47 pounds of phosphoric acid and 130 pounds of potash an acre the wheat on 51 farms increased 11.4 bushels an acre.

The composition of fertilizers varies to some extent, but the following is a fair average.

A complete fertilizer is one that contains all three of the ingredients—phosphoric acid, nitrogen, and potash. Since a crop of clover or other legumes may furnish all the needed nitrogen it is often unnecessary and expensive to buy a complete fertilizer. In such a case all that is needed is the phosphoric acid and the potash.

It is usually cheaper and more satisfactory for the farmer to buy the ingredients and mix them on the farm.

The following table shows the amount of nitrogen, phosphoric acid and potash removed from the soil by various crops.

*To reduce fats to C. H. Rule: Multiply the fats by 2¼ and add the product to the C. H.

	Amount	Nitrogen	Phosphoric Acid	Potash
		lbs.	lbs.	lbs.
Corn, grain	100 bu.	100	17	19
Corn stover	3 T.	48	6	52
Oats, grain	100 bu.	66	11	16
Oat straw	2½ T.	31	5	52
Wheat, grain	50 bu.	71	12	13
Wheat straw	2½ T.	25	4	35
Timothy hay	3 T.	72	9	71
Clover seed	4 bu.	7	2	3
Clover hay	4 T.	160	20	120
Cowpea hay	3 T.	130	14	98
Alfalfa hay	8 T.	400	36	192
Apples	600 bu.	47	5	57
Apple leaves	4 T.	59	7	47
Apple wood growth	1/50 tree	6	2	5
Potatoes	300 bu.	63	13	90
Sugar beets	20 T.	100	18	157
Fat cattle	1000 lbs.	25	7	1
Fat hogs	1000 lbs.	18	3	1
Milk	10,000 lbs.	57	7	12
Butter	500 lbs.	1	0.2	0.1
Cotton lint	500 lbs.	1.7	.5	2.3

Commercial fertilizers are bought and used for the phosphoric acid (P. A.), nitrogen (N.) and potash (P.) they contain. These elements are obtained from different substances. Some substances contain one, some two, and some all of these plant foods. Fertilizers are labeled according to the per cent of phosphoric acid, nitrogen and potash they contain. An 8-2-4 fertilizer contains 8 per cent phosphoric acid, 2 per cent nitrogen, and 4 per cent potash. (In some states the order is reversed—nitrogen, phosphoric acid and potash, and the above formula would be 2-8-4.)

The prices of fertilizing materials are subject to market changes, but are usually about as follows:

Nitrate of soda 3 cts. per lb. in 200 lb. bags
Muriate of potash 3 cts. per lb. in 200 lb. bags
Acid phosphate 1 ct. per lb. in 125 lb. bags

FERTILIZING SUBSTANCES AND THE ELEMENTS THEY CONTAIN

	Phosphoric Acid	Nitrogen	Potash
Acid phosphate	14%	.....	.....
Ground phosphate rock	32%	.....	.....
Tobacco stems	2%	1.5%	5%
Sulphate of potash (high grade)	....	.....	50%
Muriate of potash	....	.....	50%
Nitrate of potash	....	13%	45%
Kainit	....	.....	12.5%
Wood ashes (unleached)	1.5%	.....	6%
Cottonseed meal	2.8%	6.2%	1.8%
Cottonseed	1.3%	3%	1.2%
Tankage (concentrated)	1.5%	12%	.....
Dried blood (high grade)	....	14%	.....
Fish scrap	7%	9%	.....
Nitrate of soda	....	15.8%	.....
Sulphate of ammonia	....	20.5%	.....
Ammonia	....	82.4%	.....

PROBLEMS IN CONNECTION WITH FERTILIZERS

If nitrogen is worth 18 cents a pound, phosphoric acid 6 cents, and potash 5 cents, find the value of these fertilizers in each of the following problems:

In 100 bu. of corn and 3 tons of corn stover. Ans.—$31.57.

In 100 bu. of oats and 2½ tons of oat straw. Ans.—$21.82.

In 50 bu. of wheat and 2½ tons of wheat straw. Ans.—$20.64.

In 3 tons of timothy hay. Ans.—$17.05.

In 4 bu. of clover seed and 4 tons of clover hay. Ans.—$37.53.

Compare 3 tons of cowpea hay with8 tons of alfalfa hay. Ans.—Cowpea, $29.14; alfalfa, $83.76.

Compare the ravages from the soil of a crop of 300 bu. of potatoes with a crop of 20 tons of sugar beets. Ans.—Potatoes, $16.62; beets, $26.93.

Compare the cost of fertilizer elements used in producing 1000 lbs. of fat cattle with that of 1000 lbs. of fat hogs. Ans.—Cattle, $5.27; hogs, $3.47.

What is the value of the fertilizers used from the soil in producing 10,000 lbs. of milk and 500 lbs. of butter? Ans.—$11.44.

A corn crop of 80 bu. to the acre takes 146 lbs. of nitrogen, 57 lbs. of phosphoric acid and 82 lbs. of potash from each acre of land. With nitrogen worth 20 cts. a lb., phosphoric acid, 5 cts. a lb. and potash 5 cts. a lb., what is the value of the plant food removed by the corn crop? Ans.—$36.15.

A farm raises and ships away 400 bu. of wheat. With fertilizer at the same price as in the above problem, what is the value of the plant food removed? Ans.—$123.60.

Compare the value of plant food (nitrogen, phosphoric acid, and potash) removed by 500 bu. of wheat and 500 bu. of potatoes. Ans.—Wheat, $154.50; potatoes, $29.60.

What is the value of the plant food removed from a 20-acre field of oats yielding 50 bu. to the acre? Ans.—$145.50.

The barley increased 16.4 bu. per acre. At this rate find the increased profit on 40 acres with barley at 60 cents a bu. and fertilizer $2 an acre. Ans.—$313.60.

CONCRETE CONSTRUCTION

Concrete is a mixture of gravel or crushed stone, sand, and Portland cement. Concrete is used for the building of foundations, steps, sidewalks, cellars, and farm building floors, cisterns, watering and feeding troughs, fence and hitching posts, culverts, building blocks, etc.

The crushed stone and sand should be reasonably free from clay or loam and the sand should not be too fine. Walks and floors should be underdrained and should have a slope of 1 inch in 4 feet for surface drainage. Where freezing occurs walks may be underlaid with from 4 inches to 12 inches of cinders, gravel, or broken stone well wetted and very well stamped into place. Foundations and piers should extend below the frost line.

CONCRETE FORMULA

A formula is used to show the proportional amounts by volume of each of the three ingredients of concrete. A 1-2-4 concrete is composed of 1 part cement, 2 parts sand and 4 parts gravel or crushed stone.

DIFFERENT FORMULAS			AMOUNTS NEEDED FOR 1 CU. YD. CONCRETE		
Cement	Sand	Stone or Gravel	Cement, bbls.	Sand, Cu. Yd.	Stone, Cu. Yd.
1	1	...	1.8		
1	1.5	...	3.87	..	..
1	2	...	3.21	..	..
1	2.5	...	2.74	..	.
1	1.5	2	2.30	..	..
1	1.5	2.5	2.09	..	..
1	1.5	3	1.91	..	..
1	2	3	1.74	..	..
1	2	4	1.51	..	..
1	2.5	5	1.24	..	.
1	3	5	1.16	..	..
1	3	6	1.06	..	..

This formula is richer in cement than is ordinarily required. For walks, cellar floors, building walls, etc., a 1-2½-5 mixture is sufficient. For heavier work the proportion may be 1-3-6.

MIXING DIRECTIONS

Spread out the measured quantity of dry sand on a level, water-tight platform. On top of this spread the cement and turn dry with shovel until thoroughly mixed — at least three times. Then add the gravel or crushed stone. Wet thoroughly and turn again—at least three times, adding the water slowly from a sprinkler so as to make a thick mush.

For the upper course on sidewalks and floors only cement and sand are used. Since there is a space between the pieces of crushed stone or gravel it can easily be seen that a considerable volume of cement or gravel may be added to a given quantity of crushed stone without increasing the volume.

It is usually estimated that the given volume to be filled with the mixture must be increased 45 per cent in calculating the amount of materials needed. This is called 45-per-cent voids, or openings in the stone. If one had a space of 100 cubic feet to be filled with concrete, it would be necessary to order 145 cubic feet of the three ingredients.

Sand and stone are bought by the cubic yard and cement by the sack or barrel. A sack of cement is one-fourth of a barrel and weighs about 100 pounds. A barrel is estimated to contain 4 cubic feet.

PRACTICAL PROBLEMS INVOLVING CEMENT

How many cu. yds. of concrete are required in the construction of a cellar floor 14 ft. by 24 ft. and 4 in. thick? Ans.—4$\frac{4}{27}$ cu. yds.

How many cu. yds. would be required for two 3-in. floors, one 10 ft. by 12 ft., and the other 16 ft. by 30 ft.? Ans.—5$\frac{5}{9}$ cu. yds.

Find the number of cu. yds. of cinders required to make a 12-in. foundation for a walk to the barn 162 ft. long, 2½ ft. wide and 4 in. thick. Ans.—5 cu. yds.

Estimate the amount of concrete needed to build a feeding trough with walls 4 in. thick and inside measurements 10 ft. long by 18 in. wide and 10 in. deep. Ans.—14 (plus) cu. ft.

How much concrete is needed to build the walls and floor of a cellar 10 ft. by 12 ft. and 8 ft. high inside measurements, if the side walls are 8 in. thick and the floor 4 in. thick? Ans.—15 cu. yds.

Estimate concrete needed to build a circular silo 20 ft. in diameter and 32 ft. high, with 12-in. walls and 8-in. floors. Ans.—82 (plus) cu. yds.

What quantity of each material will be required in a 1-2-4 mixture for a walk to the barn 108 yds. long, 2½ ft. wide and 4 in. thick? Ans.—15.1 bbls. cement; 4.48 cu. yds. sand; 8.96 cu. yds. stone.

How many sacks of cement will be required to make 4.5 cu. yds. of a 1-2-½ mixture, also how much sand and gravel or stone? Ans.—27.2 sacks or 6.8 bbls. of cement; 2.02 cu. yds of sand; 4.03 cu. yds of stone

What would be the cost of the concrete in a walk 108 yds. long, 2½ ft. wide, and 4 in. thick, with cement costing $1.35 a bbl., sand 75 cts. a cu. yd., and crushed stone $1.25 a cu. yd.? Ans.—$35.22.

What will be the cost of the materials in a cement basement floor 15 ft. wide, and 24 ft. long, the base consisting of 1-2½-5 mixture 4 in. thick and the top coat a 1-2 mixture 2 in. thick, when material costs the same as in the foregoing problem? Ans.—Base, $14.05; top, $11.19; total, $25.24.

THE CHILDREN'S OWN BOOK

BEFORE THE CHILD GOES TO SCHOOL

How to Learn the A B C
Forming Words
Reading
Counting and Figures

LITTLE LESSONS IN THINGS BEAUTIFUL

Making Pictures of Things We See
Music
Modeling in Clay
Basketry

LITTLE PROBLEMS FOR THE WISE

Problems
Riddles
Things Difficult to Say

MYSTERY AND MAGIC

Simple Experiments with Air and Water
Knots Used by Sailors and Builders
A Trick to Play with a Book
The Disappearing Dime
Making a Ball Vanish and Reappear
Conjuring

GAMES AND AMUSEMENTS

A Little Shadow Theater
The "Alice in Wonderland" Tub
Games to Play by the Fire
Nursery Games
Garden Games
Games to Play When Out Walking
Amusing Games for Halloween

THINGS FOR BOYS TO DO

An Easy Way to Make a Telephone
The Silent Messages of the Red Man
A Magic Lantern for Picture Post Cards
Simple Kites and How to Make Them
Measuring Distances by Sound
A Simple Flying Machine
The Pleasure of a Little Garden
How to Make a Paper Box

BOY'S CARPENTER SHOP

The Tool Box
Making a Set of Book Shelves
Joints
Staining and Polishing Wood

THINGS FOR GIRLS TO DO

How to Make a Girl's Workbox
How to Use the Needle
Collecting Ferns for a Rock Garden
The Little Petticoats
The Doll's Little Frock
A Little Winter Garden
How to Make Our Own Zoo
Things We Can Make at the Dinner Table

STORIES AND PLAYS

Stories With a Mora
Stories About Animals
Stories Connected with History
Nature Stories
Stories of the Imagination
Stories of the Sea
Stories of Patriotism
Stories of Childhood
Nursery Stories
Stories of Myths
Plays for Home Production
Fables and Folk Stories

THUMBELINE FLOATED DOWN THE STREAM

Tumbeline became happy again, for everything she passed was so lovely in the sunshine, and the birds on the branches sang to her as she floated by with her pretty butterfly tied to the leaf of the water lily with her sash. (See page 371.)

A P spells AP, which is not a word at all; but if we put a C, or an M, or a T in front of it in turn, we get real words.

CAP

MAP

TAP

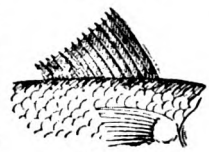
E N spells EN, and if we put first a D, or an H, or an M in front, we get DEN, HEN and MEN.

DEN

HEN

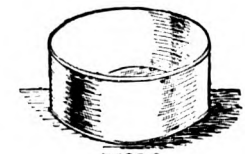
MEN

I N spells IN; put an F, or a P, or a T in front, and what do you find? Why, FIN, PIN and TIN.



FIN

PIN



TIN

One more. U G spells UG, and with an M, or a P, or an R in front, we have these very different words — MUG, PUG and RUG.

MUG

PUG

RUG

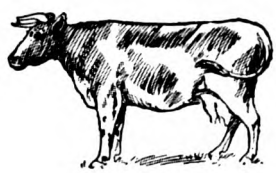
Or perhaps you can learn words better in this way:

When boys and girls are fast asleep,
And beasts go out to prowl,
If you're awake, you'll often hear
The hooting of an OWL.

OWL

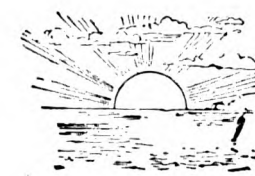
If father would give me a penny,
I would soon be inside of this shop:
It's the jolliest window of any,
And oh, how I *should* like that TOP!

TOP



COW

BOY—TOY



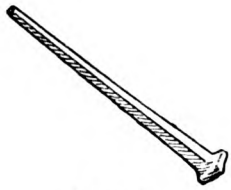
SUN

BILL

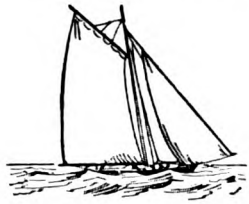
HILL

MILL

Then again, A I L spells AIL, and out of this you can make many words of four letters each. such as FAIL. HAIL, PAIL, and those given with pictures below.



NAIL

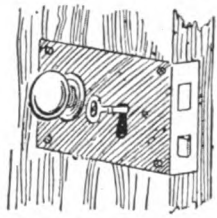


SAIL

TAIL

You will be able to make many other words from four letters. Perhaps you can make the next words out by yourselves

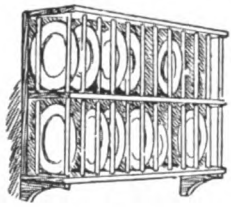
COCK



LOCK

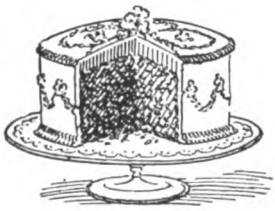
ROCK

BACK



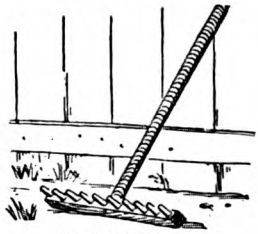
RACK

SACK



CAKE

LAKE



RAKE

STORY QUESTIONS AND PICTURE ANSWERS

Before we go on to longer words, we should be sure that we can read all kinds of short, easy words. So in this lesson we will have a few more words of three or four letters each, and then we shall be able to go on to something better.

ARK

What did Noah build to save himself, and his family, and the animals from the flood?

What did Joseph's brothers go down into Egypt to buy?

CORN

CUP

What did Joseph's youngest brother, Benjamin, find in his sack?

What bird did he send out after the raven?

DOVE

On what musical instrument did David play to comfort Saul?

HARP

LEAF

What did the dove bring back in its mouth?

LION

BEAR

What wild beasts did David kill while he was watching his father's flocks?

What did Jacob make for his little son Joseph?

COAT

PIT

Into what did Joseph's brothers throw him?

When David grew up, what did he become?

KING

ONCE upon a time the Prophet Mahomet hid from his enemies in a

CAVE

Suddenly a

TREE

in full

LEAF

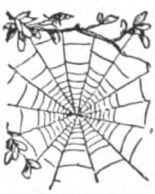
grew at the entrance of the CAVE. A

BIRD

built its

NEST

in the TREE, and a spider spun its



WEB

1
2

WE ARE GOING TO THE ZOO

1
2

THE COCK CREW

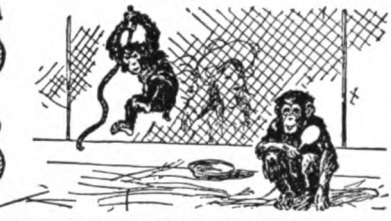
3
4

WE WILL HEAR THE LION ROAR

3
4

HEAR THE BULL ROAR

5
6

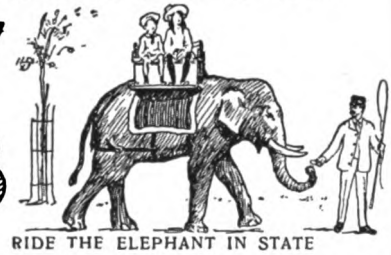


SEE THE MONKEY AT HIS TRICKS

5
6

THE CLOCK TICKS

7
8



RIDE THE ELEPHANT IN STATE

7
8

CLEAN THE GRATE

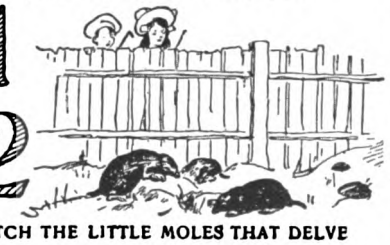
9
10

FEED THE BEAR IN HIS DEN

9
10

ARE PIT-MEN

11
12



WATCH THE LITTLE MOLES THAT DELVE

11
12

FOR COAL THEY DELVE

THE HOUSE THAT JACK BUILT

THIS is the house
that Jack built

THIS is the malt
that lay in the house
that Jack built.

THIS is the rat that ate the malt
That lay in the house that Jack built.

THIS is the cat
That killed the rat that ate the malt
That lay in the house that Jack built.

THIS is the dog
that worried the cat
That killed the rat that ate the malt
That lay in the house that Jack built.

THIS is the cow with the crumpled horn
That tossed the dog that worried the cat
That killed the rat that ate the malt
That lay in the house that Jack built.

THIS is the maiden all forlorn
That milked the cow with the crumpled horn
That tossed the dog that worried the cat
That killed the rat that ate the malt
That lay in the house that Jack built.

THIS is the man all tattered and torn
That kissed the maiden all forlorn
That milked the cow with the crumpled horn
That tossed the dog that worried the cat
That killed the rat that ate the malt
That lay in the house that Jack built.

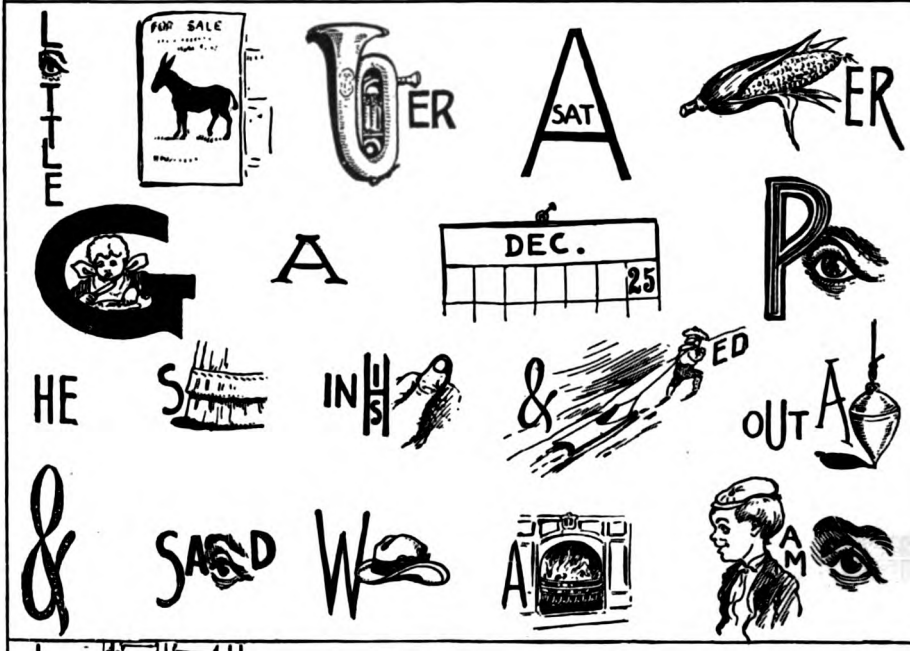
THIS is the priest all shaven and shorn
That married the man all tattered and torn
That kissed the maiden all forlorn
That milked the cow with the crumpled horn
That tossed the dog that worried the cat
That killed the rat that ate the malt
That lay in the house that Jack built.

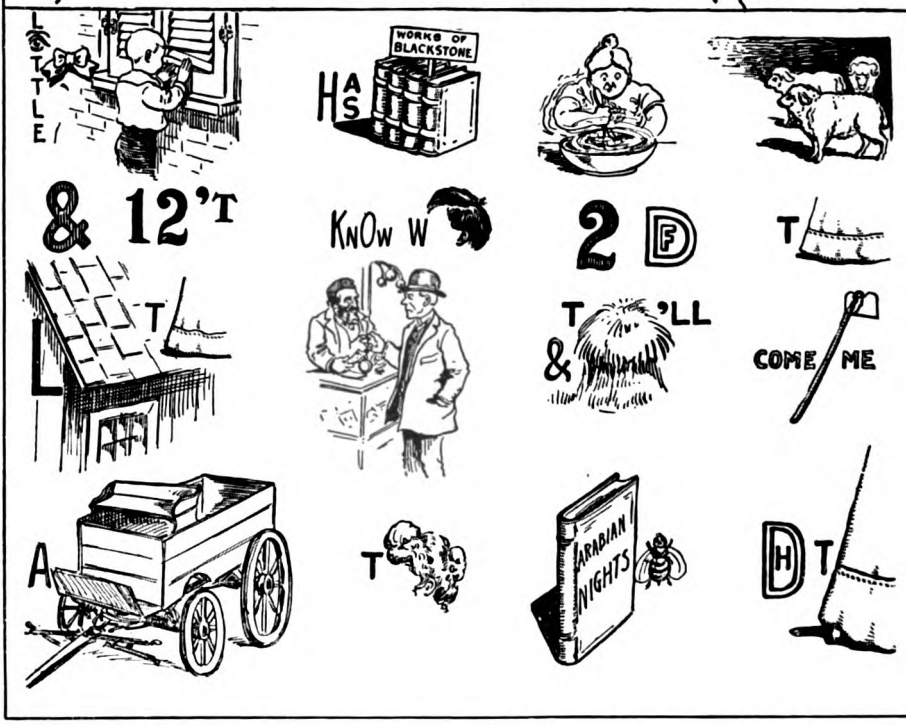
THIS is the cock that crowed in the morn
That wakened the priest all shaven and shorn
That married the man all tattered and torn
That kissed the maiden all forlorn
That milked the cow with the crumpled horn
That tossed the dog that worried the cat
That killed the rat that ate the malt
That lay in the house that Jack built.

THIS is the farmer sowing the corn
That kept the cock that crowed in the morn
That wakened the priest all shaven and shorn
That married the man all tattered and torn
That kissed the maiden all forlorn

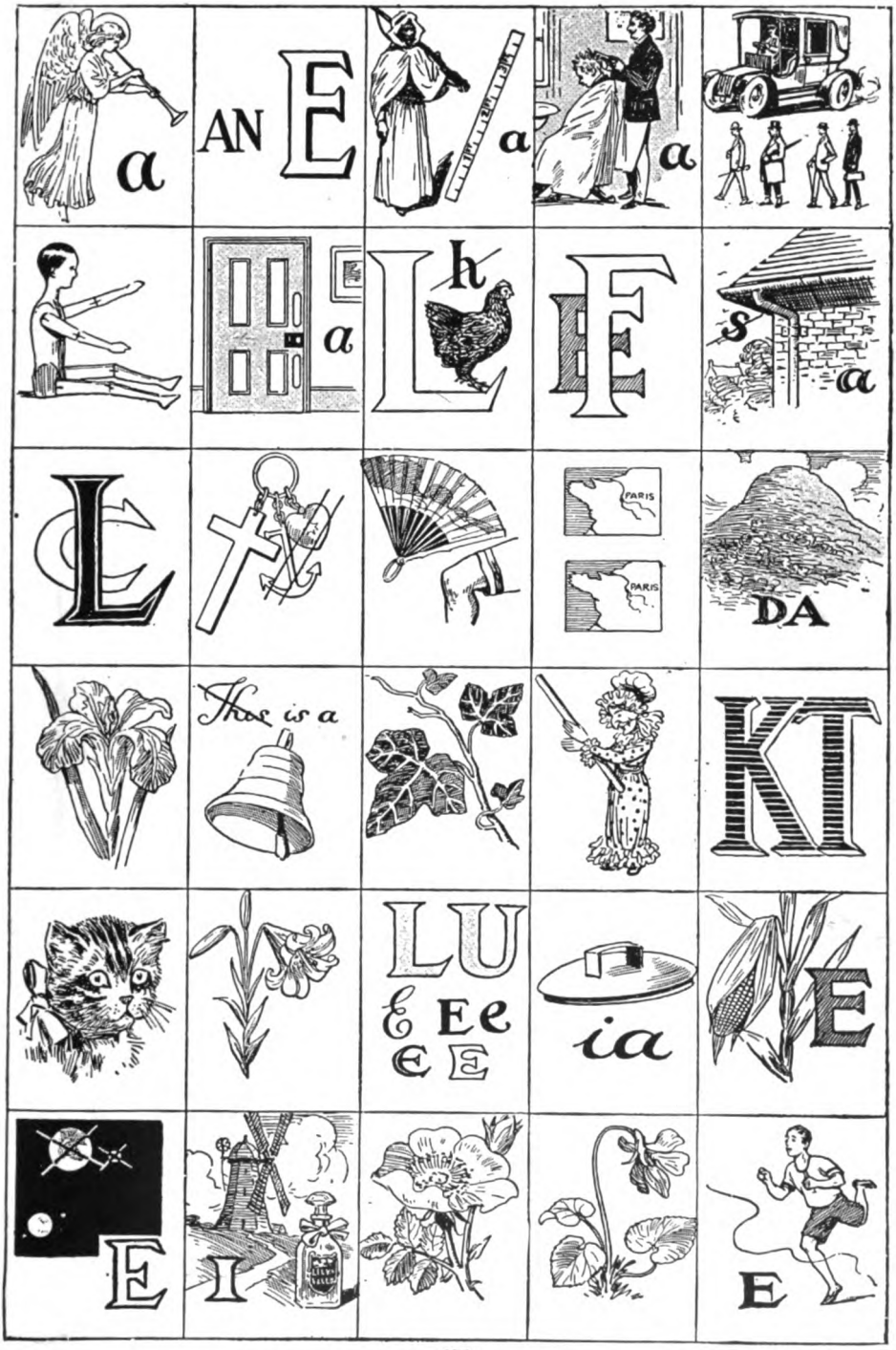
That milked the cow with the crumpled horn
That tossed the dog that worried the cat
That killed the rat that ate the malt
That lay in the house that Jack built.

MOTHER GOOSE IN REBUS

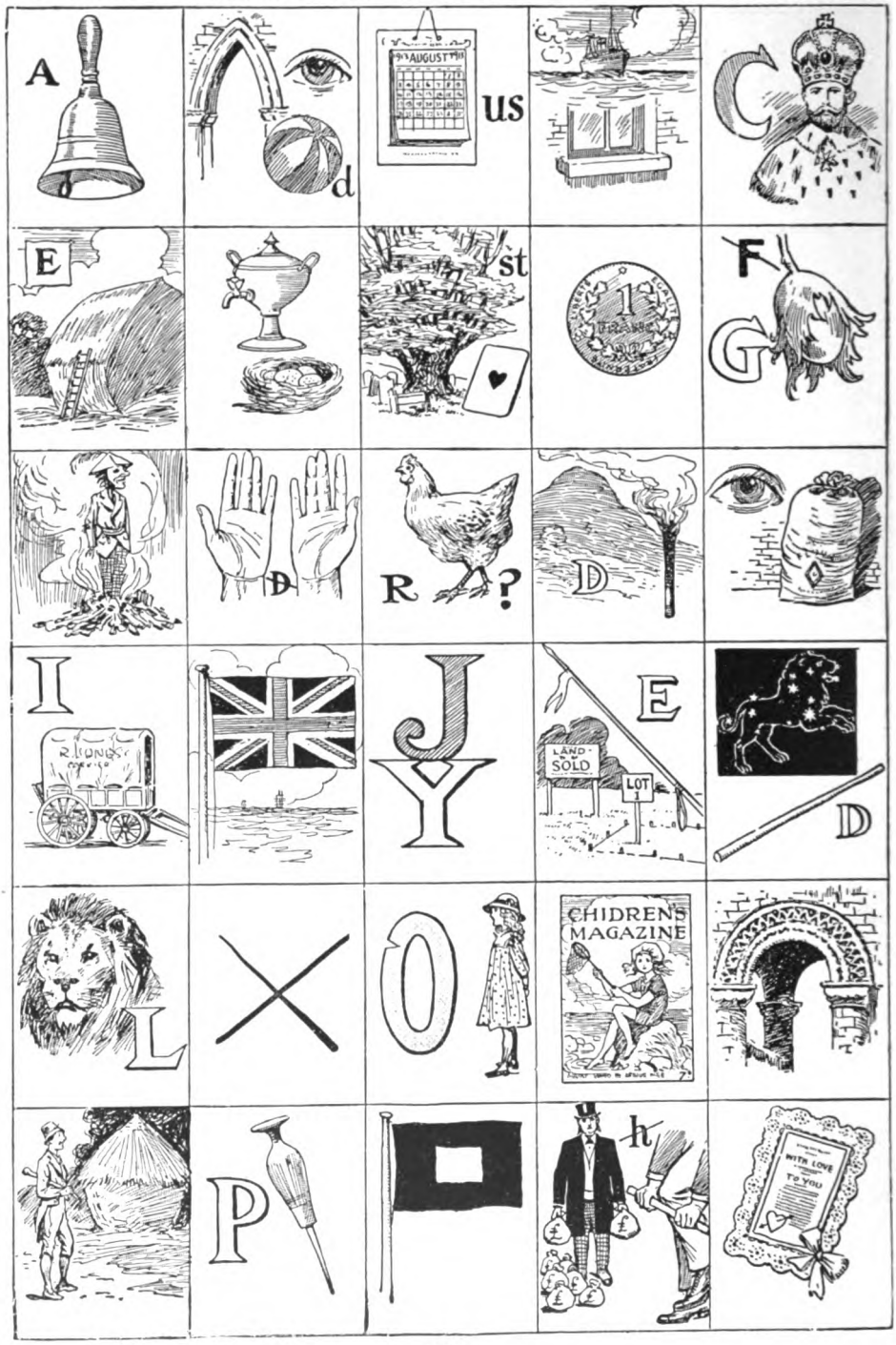




IS YOUR NAME IN THESE GIRLS' PICTURES

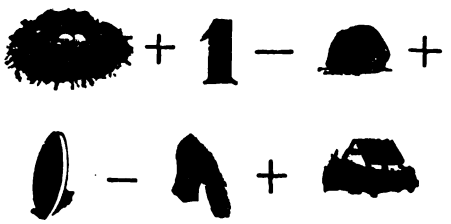


IS YOUR NAME IN THESE BOYS' PICTURES?



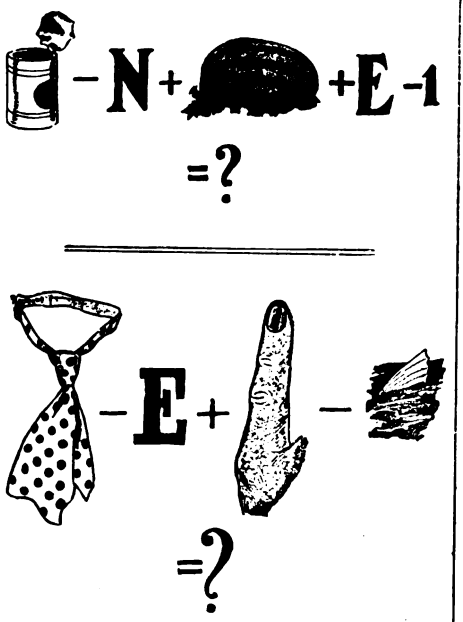
SAM LOYD'S PUZZLES

GEOGRAPHICAL PUZZLES 43



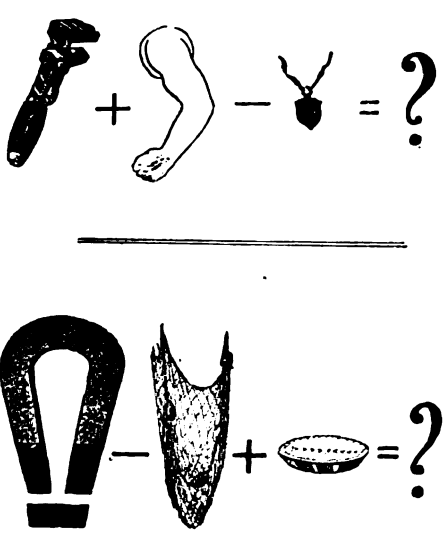
WHAT TWO AMERICAN CITIES DO THESE SUMS SPELL?

ZOOLOGICAL PUZZLES 69



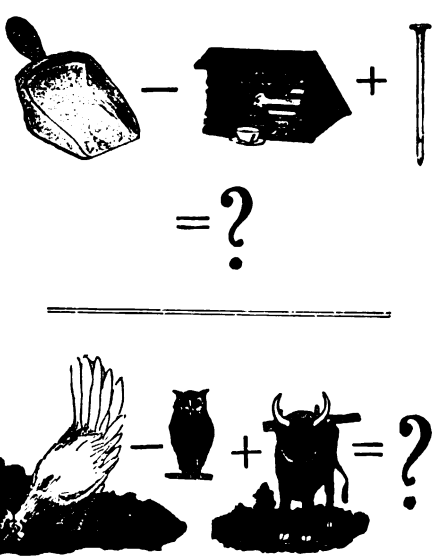
WHAT TWO ANIMALS DO THESE SUMS SPELL?

BIRD PUZZLES 87



WHAT BIRDS DO THESE SUMS SPELL?

PUZZLE SUMS 76



NO. I. WHAT REPTILE DOES THIS SUM SPELL?
NO. II. WHAT ANIMAL DOES THIS SUM SPELL?

SAM LOYD'S PUZZLES

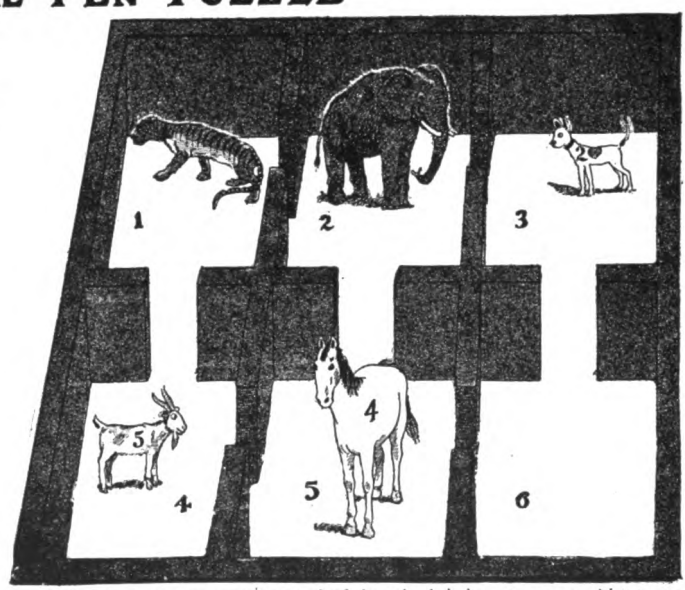
PUZZLING NOISES

99

The young musician is surrounded by a variety of noises. Number one is plainly a squeak. How many other noises can you find in the little pictures?

THE PEN PUZZLE

117



In how few moves can you place each of the animals in its proper pen, without ever having two in the same pen? The numbers on the animals should correspond to the numbers of the pens.

43 1st. Nest + One − Stone + Wheel − Heel + Ark = Newark.
2d. Wheel + Pie + Ring − Pier = Wheeling.

69. 1st. Can − N + Melon + E − One = Camel.
2d. Tie − E + Finger − Fin = Tiger.

87. 1st. Wrench + Arm − Charm = Wren.
2d. Magnet − Net + Pie = Magpie.

76. 1st. Scoop − Coop + Nail = Snail.
2d. Fowl − Owl + Ox = Fox.

99. 1, Squeak; 2, Squall; 3, Howl; 4, Roar; 5, Bellow; 6, Ring; 7, Growl; 8, Wail; 9, Bark.

117. The animals are rearranged into their proper pens by moving them in the following order: 4, 3, 2, 4, 3, 5, 1, 2, 4, 3, 5, 4, 2, 1, 4, and 5.

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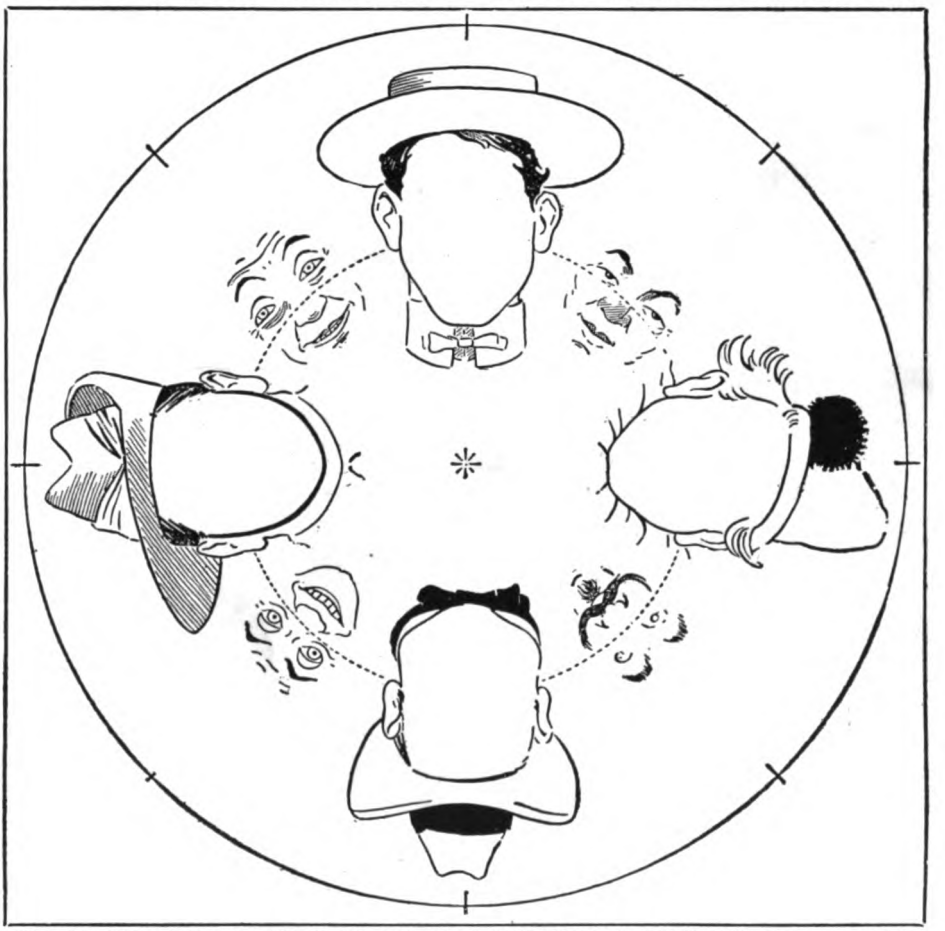
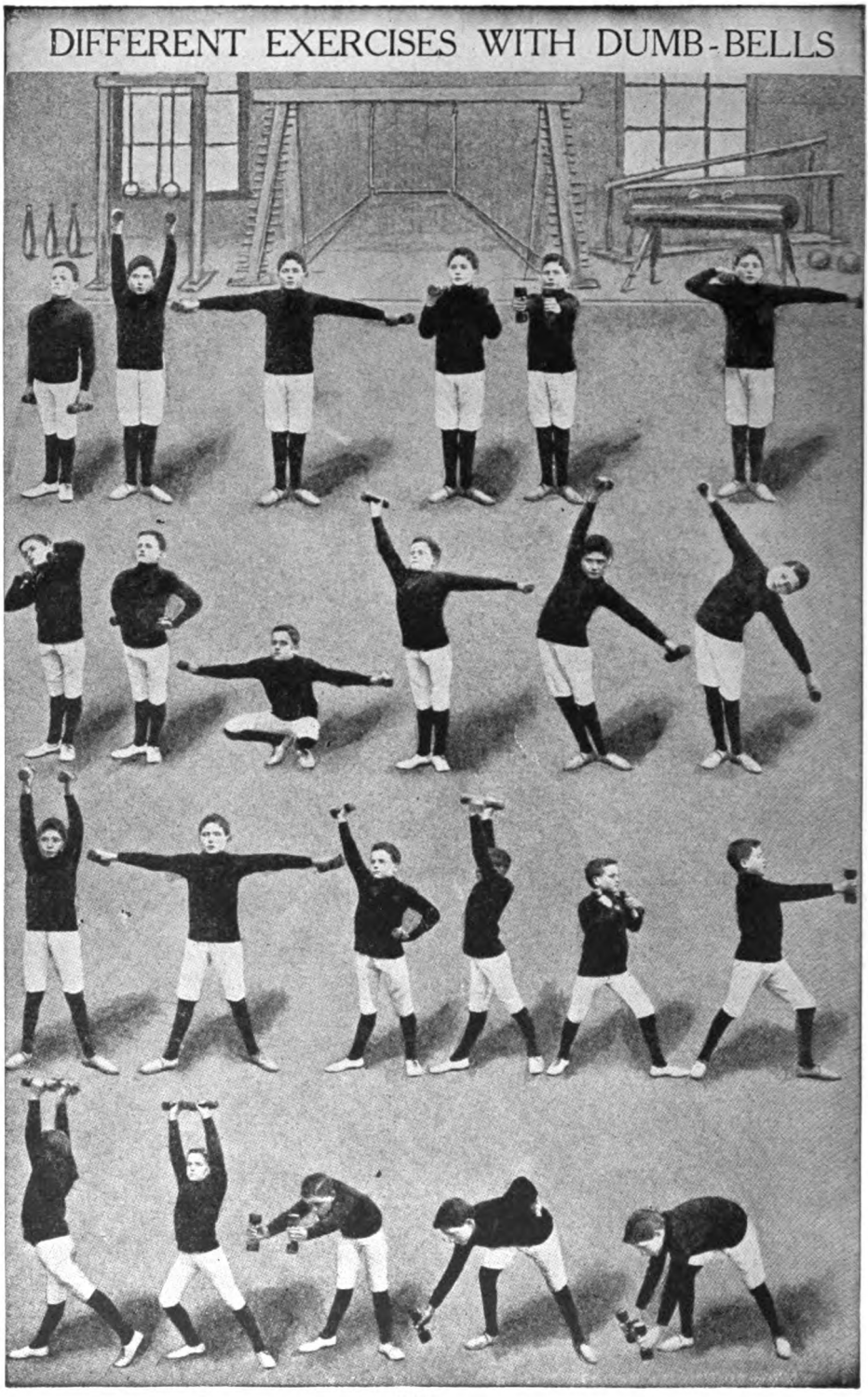
HOW TO DRAW HUNDREDS OF FACES

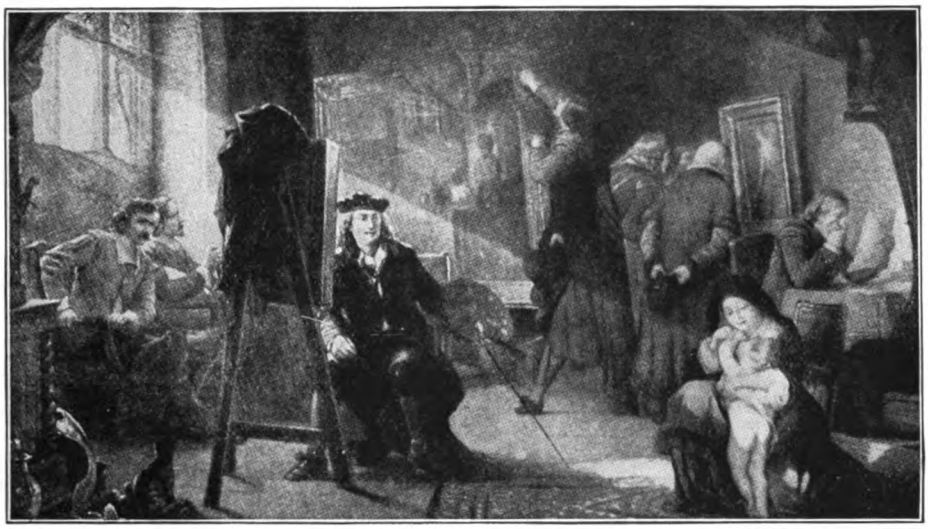
With the diagram on this page we can draw hundreds of different pictures, even though we may not be artists in any sense of the word. First of all, we should take a piece of good tracing-paper and trace the diagram upon it quite carefully and accurately. Then we should ink over the lines, and when the ink is quite dry paste the tracing-paper with the design upon a piece of cardboard. To do this, cover the card with a smooth paste and lay the tracing-paper upon it, smoothing out all wrinkles with a clean cloth. When this is dry, we are ready to draw any number of faces. Take a piece of tracing-paper and pin it down upon the card, pressing the pin through the centre of the diagram where a star is marked. Now we must trace any one of the hats upon the transparent paper. Then let us turn the paper round until the hat that we have drawn comes over one of the other hats in the diagram. Now trace the shape of the face that appears under our hat. Again turn the tracing-paper round until one of the pairs of eyes comes into position within the outline of a face that we have drawn. Trace the eyes with pencil, and finally turn the paper round to another position and trace a nose and mouth. We now have a complete face with eyes, nose and mouth, hair, and hat.

By ringing the changes and drawing the different eyes in the different face outlines, and putting sometimes one hat or mouth and sometimes another, we are able to make hundreds of different pictures. There are one or two things to remember if we want to be successful in thus producing an imaginary portrait gallery. The tracing-paper must be pinned down firmly upon the card and must not be allowed to shift about, or the different parts of the different faces will not join up properly. Then we should use a soft black lead pencil in tracing the faces, and we must not press too heavily or we shall indent the card and spoil the diagram. We can ink over the pencil-lines afterwards.



BY FOLLOWING THE DIRECTIONS, WE CAN, FROM THIS DIAGRAM, DRAW HUNDREDS OF FACES


DIFFERENT EXERCISES WITH DUMB-BELLS



Rembrandt in his studio

LESSONS IN THINGS BEAUTIFUL AND USEFUL

SHAKESPEARE says in one of his plays that if we could cast off this "muddy vesture of decay" we should be able to hear the "music of the spheres." He means that if we were more thoughtful and quiet, we should find that all the sights and sounds about us are really beautiful and pleasant and that if they do not seem so to us the fault is not in these things, but lies in ourselves.

Now artists—who include poets, writers of books, musicians, painters, designers, sculptors, and architects—are those who hear this "music of the spheres," and put it down so that the rest of us may hear it too.

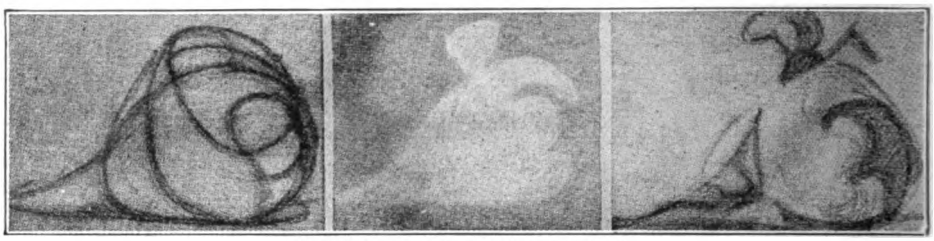
Let us try to find out how this music is heard by painters and designers, architects and sculptors, and how they write it down. We know all beautiful things by our minds or our souls. Our eyes, ears, touch, taste, and smell are only the roadways to our true selves, so that music may travel by any one of these paths, and not by the ear roadway only.

And music does not mean only pleasant sounds coming together; it means also beautiful shapes falling side by side, or colors, placed one against another. So that, when we see a beautiful picture, or a piece of sculpture, or a grand building, or a lovely decoration, the music of the arrangement of the shapes is appealing to our eyes, and giving us joy and pleasure quite apart from the subject of the work. In these pages are some pictures with their musical shapes. Look carefully at them, and see if you can find any of this music. Look carefully to see if one line appears to be the continuation of another, though there is no actual connection. Join these lines, and note the beautiful shape they enclose.

Again, boys and girls, men and women, the flowers and trees, the birds and animals, the earth itself are all struggling for existence. The very winds, the clouds, and the sunshine are all the results of struggling, of fighting, of victory, and of failure.

Joy and sorrow touch everything on earth, and he is an artist who is able to picture this joy and sorrow for us so that we can feel them strongly.

So an artist must possess two things—an eye quick to see and love beautiful shapes, and a mind quick to feel and to respond to the joys and



How the hand of the artist draws a picture

struggles that all the things about us are enduring—that is, he must want to rejoice with glad things, to be sorrowful with sad things, to admire all brave efforts, wherever they are made and whatever makes them.

All of us possess more or less these two essentials—the quick eye and the sympathetic mind. We do not always realize it, and we are too often afraid of our feelings. Now this is wrong, for if we would become brave and tender men and women, capable of doing big and effective work in the world, we must reverence our thoughts and feelings, and not be ashamed or afraid of them.

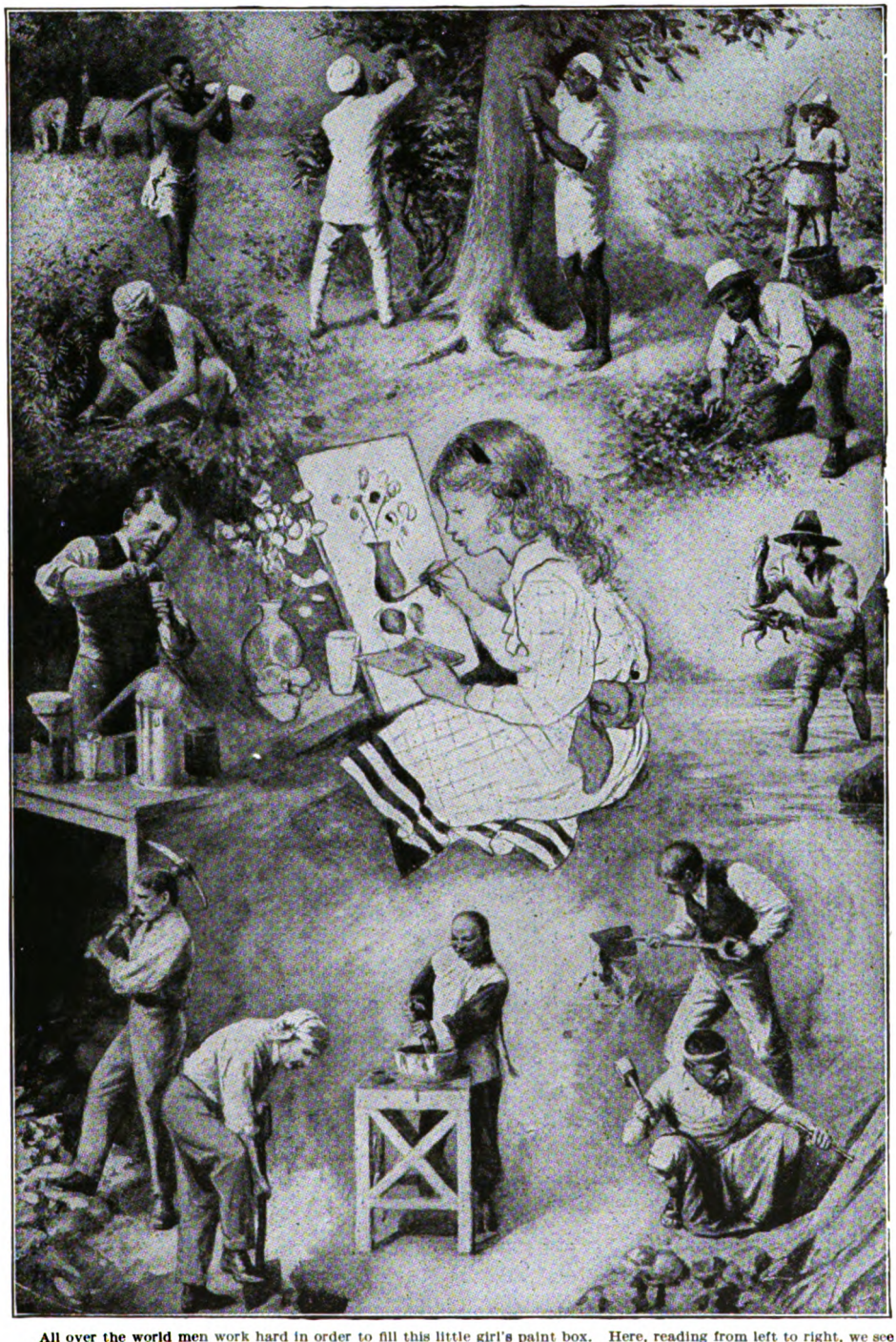
Now, though drawing is music, it is also speech, and we draw in order to tell to others facts that we could not put so well into any other form, things that give us pleasure which we would share with others.

The completed picture

It is not possible for us all to become great artists, but we should all be able to read what the artist is eager to tell us in his work, and by reading his pictures our lives will become bigger and more sympathetic. We shall begin to see the beautiful laws of order and music that are at the heart of everything, and then we shall want to link this music together ourselves, in order to make others feel it as we do, and we, too, may be artists, creators. So let us set about our lessons in this wonderful subject, whereby we shall become friends with the things around us.

MATERIALS: For the little ones we will choose white and colored crayons, these should be soft and not greasy. The mind must work readily through the fingers and the muscles of the hand must become very sensitive, which cannot happen if hard unyielding pencils are used. You who are older may use pencils, which must be soft known as B or BB so that they will yield readily to the slightest pressure. If you have a paint box you must learn to use it. These boxes containing moist colors in pans or tubes are preferable. With these you will need

THE WORLD AT WORK TO FILL A PAINT-BOX



All over the world men work hard in order to fill this little girl's paint box. Here, reading from left to right, we see **men collecting ivory for black**, insect-cells for crimson lake, resin for gamboge, cochineal for carmine, the indigo plant for **indigo, the madder for brown**, iron and potassium for Prussian blue, cuttlefish for sepia, earth for sienna, mercury for ver**million, and mineral for ultramarine.**

a pointed camel's hair brush, number six, a jar for water, and a small sponge-box, water and sponge must be kept quite clean. Untidy materials make an untidy mind.

Use white or colored paper to work on. There is a cheap unglazed, soft-textured, warm gray paper which is delightful, and which may be obtained from any dealer in artists' materials. Ordinary unglazed brown paper is good if neither too light nor too dark. Do not let your paper become creased or crumpled, keep it flat and neatly together in a portfolio. The portfolio may be bought or made at home from two pieces of cardboard joined together at the back and fastened at the front with a piece of tape.

A small drawing board will be necessary to which the paper should be fixed by four thumb tacks or drawing pins. When drawing do not lay your board flat upon the table, let it slope toward you resting the top against the table.

Sit well away from your work, hold crayon, pencil or brush lightly with end of same pointing into the palm of your hand, and your hand scarcely touching the paper as you work.

Face squarely the object you wish to draw so that you may glance quickly from your drawing to the object. Hold your work frequently at full arms length from you, or better still stand away and look at it as though you were a teacher correcting exercises.

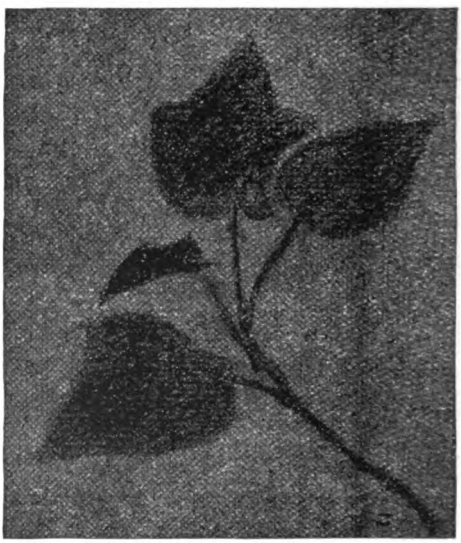
Forget yourself and do not be afraid of your materials. Think only of putting down on the paper just the appearance of the object before you.

THINGS TO DRAW

All living things, if they have been allowed to grow up without suffering from accident, have beautiful shapes. We cannot do better than to draw, from every possible view, the things we see about us and so learn to recognize a beautiful shape before we consider the second great essential underlying all art—that is, the true self of everything.

When using crayons do not press heavily or you will fill every crevice of your paper, then the color of the paper will not show through the crayon as a soft gray. If your drawing is not

This is how the laurel spray should look when it is drawn from memory in black chalk on brown paper.



If we have chosen ivy leaves to draw instead of laurel leaves, this picture will do to compare our drawing with.

good, do not try to rub it out, make it again and again.

DRAWING AND PAINTING A SPRAY OF LEAVES

Let us find and draw or paint a spray of leaves. Any kind of leaves will do but since all leaves and flowers change quickly after they are picked we will need to work rapidly. You will notice that wherever the leaf springs from the stem there is a little swelling; sometimes it is much bigger than at other times

The stalk of the leaf is not the same thickness all the way down. Some kinds of laurel leaves are rounded at the tips and where they join the stalks and some are pointed. Whichever kind of leaf we have chosen, we must look at all these things and notice the different shapes, begin with the big stem. Notice if it curves or bends, then draw the leaf-stalks and then the leaves themselves. We shall find it better not to draw the leaves with a single line round them at first, but to rub the chalk sideways on the paper, getting the direction the leaf takes carefully, and drawing it big. The pictures show laurel and ivy, but any leaves must be drawn in the same way, beginning first with the long stems. We can practice drawing the spray with a brushful of color in green paint to match the shade of the leaves, or in brown or black paint like the picture above. Moisten the paper with the damp sponge first. If the paper glistens when you hold it level with the eye, it is too wet.

A good, bright green is made by mixing Prussian blue, gamboge, and burnt sienna. A good dark green is made by mixing together indigo and burnt sienna or Prussian blue and Vandyke brown. We shall find that there are a great many ways of mixing greens when we know our paints.

Remember that we draw with our mind, and that our hands can do only what our mind, or soul, tells them. If we do not look at the object carefully, and judge its edges carefully, our hands cannot put the truth down.

Now we have to make a copy of our laurel leaves, painting them straight away on white paper.

Here is a picture of a spray of ivy leaves painted on white paper. Remember to start with the stalk.

A PLAY LESSON

Now let us have a play lesson. Take one of the things you think you can draw, place it before you, and look at it for a minute or two. Then cover it up and try to draw what you have seen from memory.

When you have finished your drawing, uncover the object, get up from your seat, stand behind your work and compare it with the original. Be a teacher, and do not allow any fault to go uncorrected.

Do this with every object—the cat, the dog, your toys, leaves, fruits, and flowers—about you. Look at it, turn away and draw it; then change yourself into a teacher and criticize. You must be a judge, and bring up every accusation you can. You must definately and fairly judge each one—length against breadth, curve against curve. You cannot realize too clearly how important this part of your work is.

You will never draw freely, or forget your pencil and paper and yourself, until you can draw from memory. It is only then that you can be said to know what an object is like.

THE LITTLE CLAY MODELER AT HOME

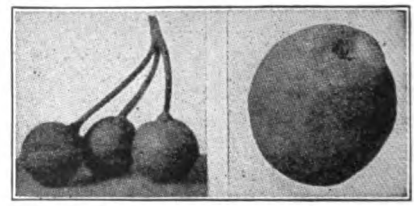
A SIMPLE LESSON IN AN INTERESTING PASTIME

THOSE of us who have ever done modeling will agree that it is a delightful pastime. There is no end to the things that can be made out of those little lumps of clay which look so uninteresting till they have been pinched and poked and rolled into all manner of fascinating shapes. And modeling is as useful as it is delightful, for it not only makes practical use of our patience and our perseverance, but it trains the senses of sight and touch, and makes us observant, and consequently more accurate and self-reliant.

The "tools" that are needed are few in number, and quite inexpensive. All that is required is a piece of clay, or, better still, of plasticine—which is cleaner to work with and better in many ways—an unframed slate, and one's fingers. Of course, the more plasticine the better, and the gray color is the most suitable for the work it is proposed to do. It can be bought at almost any shop in which artists' materials are sold, and a slate may be procured from a shop dealing with school requisites.

Just a word as to the care of the materials. Keep the plasticine in a moderately cool place, and when not in use see that it is kept free from dust or grit. After long usage, plasticine has a tendency to become stiff and difficult to manipulate. This is owing to the evaporation of the oil which it contains. When it becomes so, work a small quantity of vaseline into it by kneading in your hands until it becomes plastic again. The slate should always be scraped clean before each model or exercise is attempted.

The first few models will not need to be worked on the slate at all; they must be done almost entirely in the hands and with the finger-tips.

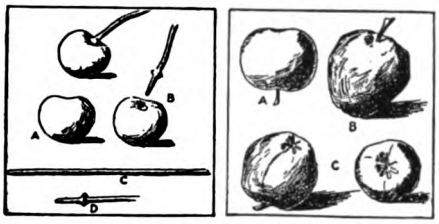


Let us take the first picture—a model of a bunch of cherries. Break off—do not cut—a lump of plasticine and roll three balls about the size of cherries. Slightly press the top of

each to give the shape shown at A, and in the center of each depression bore a hole, as at B, with a match, to receive the ends of the stalks. For the stalks, roll out on a clean slate a long thin strip, as at C. To do this successfully, and to preserve equal thickness throughout the length, requires care. The small piece of plasticine used should be rolled beneath the flat hand on the slate, and not between the two hands. Press evenly as the strip begins to lengthen, and move the hand slowly to the right as you proceed with the rolling. The right thickness to obtain is equal to that of an ordinary match. This is, of course, a little thicker than the natural stalks of the cherries would be; but we take a little liberty, for if we reduced them to such a degree they would hang limply down. Divide the strip into three equal lengths, and make the little thickening, as shown at D, by lightly holding the strip between fingers and thumbs and pressing with both hands at once towards the thickening. Fix the stalks into the cherries, pinch the three ends together, and the model is complete.

Our other model is an apple, and this will demand a greater effort. Of course, there are many shapes of apples and a round one as at A, with just the end depressions and the stem, would be very easy to make.

But the apple we wish to do is one



with a well-defined and somewhat angular shape, of the type shown, exaggerated a little, in the illustration marked B. This is much more difficult. The size of the model must be left to the worker for it must not be too big to handle comfortably. First, make a ball as before, and, with the real apple before you, work it into the same shape adding to or taking from the model as you proceed. You will find the finger-tips very useful for this. Notice all the little angularities of surface, look well at the copy from every side, and compare the two constantly as you work. Do not be satisfied merely with the model of an apple, but try to make a faithful copy of the apple before you. The stem is inserted in a similar manner to those of the cherries, and the markings at the opposite end are made with the match end as at C.

The model should have a smooth finish, and this can be done by lightly smoothing with the forefinger. It must be held carefully and without undue pressure while this process is being carried out.

BASKETRY

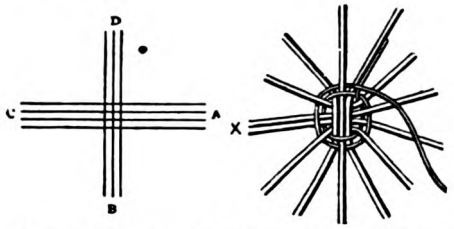
BASKETRY—A DOLL'S CHRISTMAS HAMPER

WHILE we are enjoying the good things that Christmas brings, we surely must not forget our dolls. Here we are going to learn how to make a little doll's hamper, and later on to fill it with Christmas "goodies" which we shall find it quite easy to model with our fingers out of clay.

First, then, we will make the hamper, for which we must carefully measure off seven pieces of "No. 4" (or fairly thick) cane. Most of the big toy-shops sell cane for cane-weaving, or, of course, it can be bought from any basket factory.

If we make the hamper three inches high, each piece of cane must be sixteen inches long. These seven lengths of cane are for the foundation of our hamper, and we will call them the "spokes" whenever we refer to them, as they remind us of the spokes of a wheel.

Form a cross with four spokes across and three spokes upright, the three upright spokes being in front as in picture 1.



1. Position of the canes 2. Beginning to make the basket

Hold these between the thumb and first finger of the left hand.

Our next step is to select a long piece of "No. 1" (or fine) cane, which we shall call the "weaving-cane," as it weaves in and out the spokes, just as the threads of any woven material pass over and under each other.

We must hold the weaving-cane in our right hand, a few inches from one end. Place this *end* of the weaving-cane at the dot in picture 1, and pass it under the four spokes at A, over the three spokes at B, under at C, and again over at D. We draw this as tightly as possible and pass the cane under the tiny end to form a *tie.*

In picture 2 we are able to see just how the weaving-cane travels, if we follow it up from the letter L.

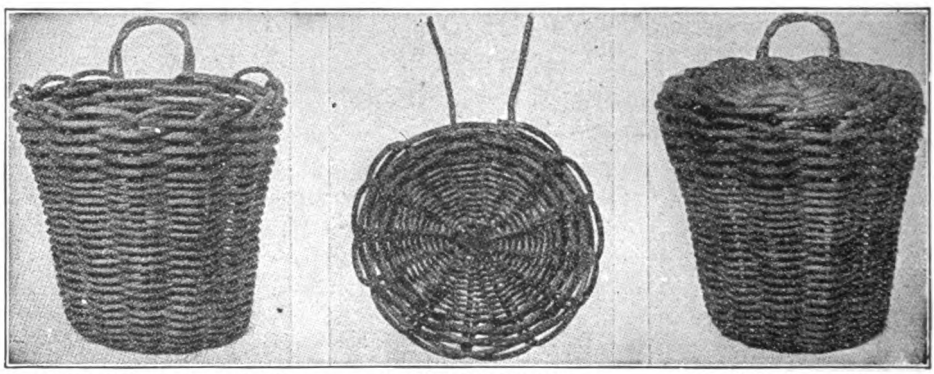
From this point we weave over one spoke and under the next until we have passed eight spokes, which brings us to the left side of the picture where we see two spokes taken together. Some of us may think this a mistake, but in weaving we must have an odd number of spokes, because where the weaving-cane passes over one time, the next time it must go under.

At the place marked X in picture 2, we take two spokes together and treat them just as one spoke.

By taking the two together it fastens the odd number in quite securely. Continue the weaving over and under, taking care, when you come to the spoke with the little bit beside it, that you treat that spoke and the little bit as one. We must remember always to weave in the direction in which we began.

If we have done our weaving correctly, the weaving-cane will now pass under the spoke over which it went the last time round.

We must continue our weaving until we have covered about one inch from



3. The basket without the lid 4. The lid of the basket 5. The basket complete

the center of the basket. Then cut off one of the two spokes taken together and what is left of the tiny bit of weaving-cane where we started.

One very important thing is the right way to hold our work. Hold the work in the left hand perpendicularly, the weaving-cane being held in the right hand just like a skipping-rope about two inches away from the basket. We now slip the first finger out and hold the cane between the thumb and the second finger.

Don't think Mr. First Finger has nothing to do. He is a very important person, and acts as a guide to Mr. Weaving-cane, guiding and pressing him always into his proper place. We must also be very careful never to pull the weaving-cane, but to bend it round the spokes, moving the basket up and down at the same time.

Every touch of our fingers has a permanent effect on the ultimate shape of our basket, and no subsequent pressure will alter it. We shall be able to begin a second basket much better after we have thus learned to weave properly.

How are we to turn up the cane for the sides of the hamper?

We notice the alternate spokes are on the top of the weaving-cane. These spokes we bend away from us. Weave round once again, when, of course, the other spokes are on the top. These also must be bent away from us. We continue weaving as before, taking care to keep the spokes nearly at right angles to the bottom of the basket.

We must remember, as we weave the side of the hamper, when the weaving-cane is going behind a spoke, to draw that spoke back with the guiding finger and slip the whole hand behind it to put the weaving-cane in place. The more we press on the spokes when drawing them back, the more the sides of our basket will slant outwards.

By this time the side of our hamper measures two and a half inches from where we turned it up. Here we take a length of No. 4, or rather thick cane to weave the other half-inch. An important point to learn just now is how to join a new piece of cane so that it will be least observable.

We must always finish off the end of the old weaving-cane, when we have come under a spoke, by pushing the loose end of the weaving-cane down the side nearest to us of the same spoke.

Take a new piece of weaving-cane and pass the end down the far side of this spoke. Both the old and the new weaving-cane pass behind the same spoke, but the join does not show on the right side of the basket.

To finish our basket we cut an inch off each spoke with the exception of two, which we leave to form the handle, as seen in picture 3. Each spoke must be turned back the opposite way from which we have been weaving, and pressed down the far side of the next spoke until it lies level with the last line of weaving. To form the little handle, we cross the two spokes and push the ends down so that one end goes in where the other starts from.

Having made our hamper, we must turn our attention to the lid for it, which is made exactly as the bottom of the hamper, using seven spokes about six inches long.

When the weaving exactly fits the top of our hamper, we finish by pushing the spoke-ends down the sides of their left-door neighbors.

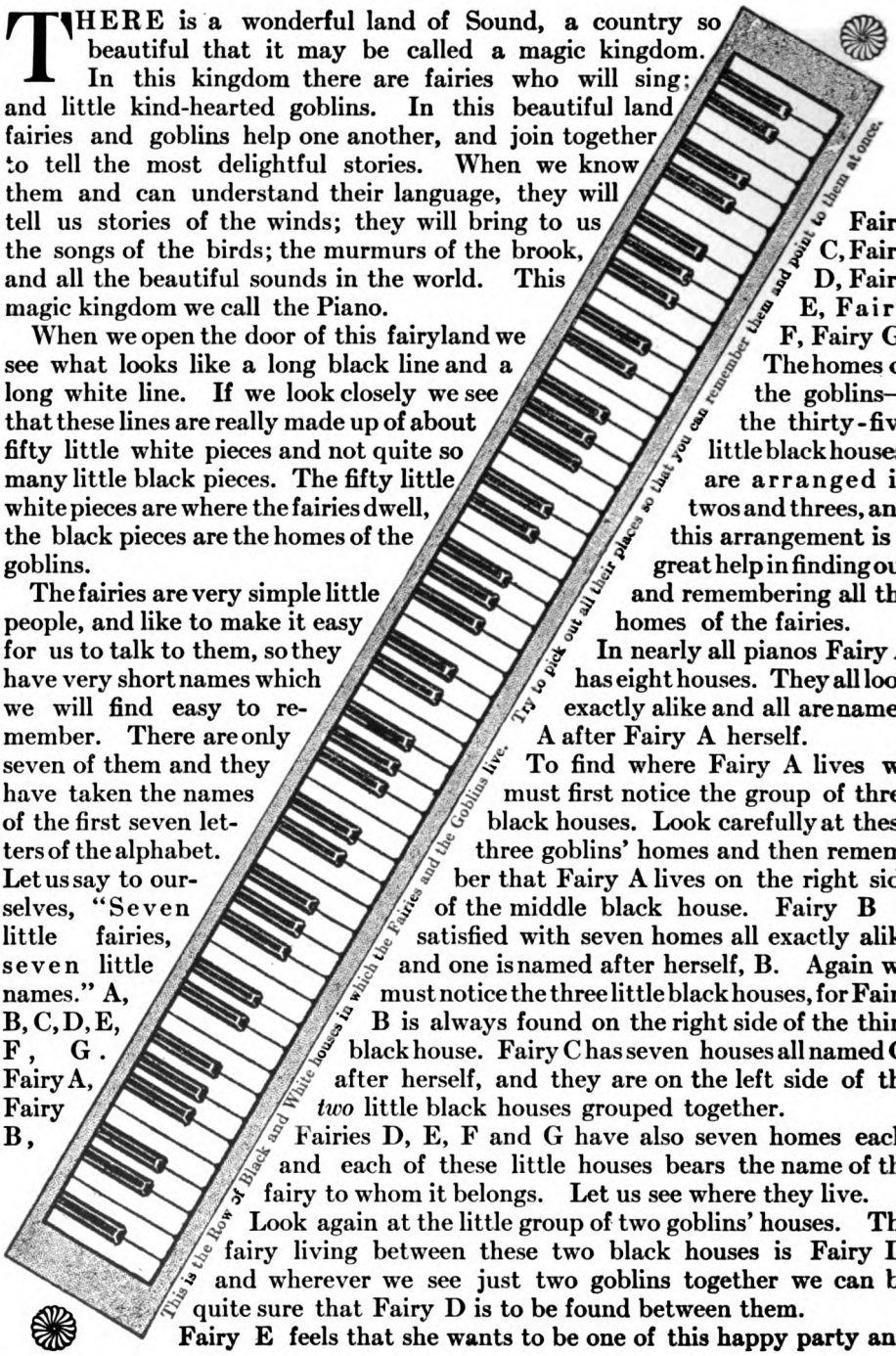
Basket-weaving is most fascinating work when once we have acquired the art of weaving easily; therefore it is worth while to practice weaving, as from this small beginning it is possible to make any number of very pretty and useful articles.

THE WONDERFUL LAND OF SOUND

THERE is a wonderful land of Sound, a country so beautiful that it may be called a magic kingdom. In this kingdom there are fairies who will sing; and little kind-hearted goblins. In this beautiful land fairies and goblins help one another, and join together to tell the most delightful stories. When we know them and can understand their language, they will tell us stories of the winds; they will bring to us the songs of the birds; the murmurs of the brook, and all the beautiful sounds in the world. This magic kingdom we call the Piano.

When we open the door of this fairyland we see what looks like a long black line and a long white line. If we look closely we see that these lines are really made up of about fifty little white pieces and not quite so many little black pieces. The fifty little white pieces are where the fairies dwell, the black pieces are the homes of the goblins.

The fairies are very simple little people, and like to make it easy for us to talk to them, so they have very short names which we will find easy to remember. There are only seven of them and they have taken the names of the first seven letters of the alphabet. Let us say to ourselves, "Seven little fairies, seven little names." A, B, C, D, E, F, G. Fairy A, Fairy B, Fairy C, Fairy D, Fairy E, Fairy F, Fairy G. The homes of the goblins—the thirty-five little black houses, are arranged in twos and threes, and this arrangement is a great help in finding out and remembering all the homes of the fairies.



In nearly all pianos Fairy A has eight houses. They all look exactly alike and all are named A after Fairy A herself.

To find where Fairy A lives we must first notice the group of three black houses. Look carefully at these three goblins' homes and then remember that Fairy A lives on the right side of the middle black house. Fairy B is satisfied with seven homes all exactly alike and one is named after herself, B. Again we must notice the three little black houses, for Fairy B is always found on the right side of the third black house. Fairy C has seven houses all named C, after herself, and they are on the left side of the *two* little black houses grouped together.

Fairies D, E, F and G have also seven homes each, and each of these little houses bears the name of the fairy to whom it belongs. Let us see where they live.

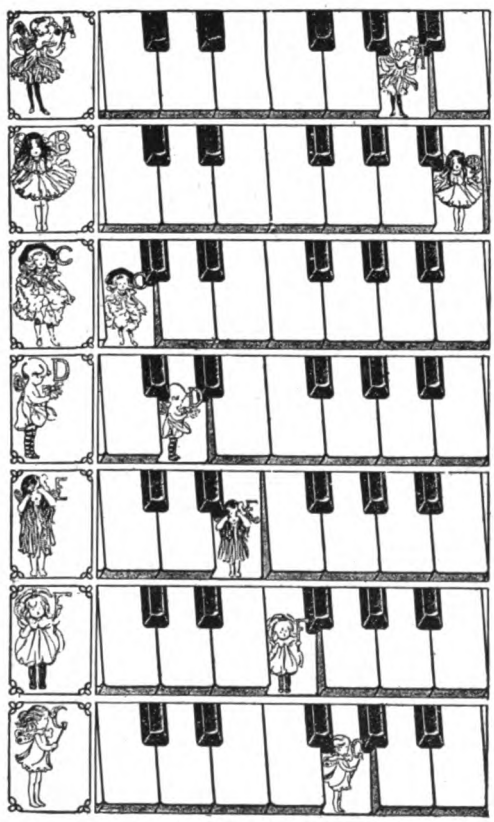
Look again at the little group of two goblins' houses. The fairy living between these two black houses is Fairy D, and wherever we see just two goblins together we can be quite sure that Fairy D is to be found between them.

Fairy E feels that she wants to be one of this happy party and

she has her home next to D, so that Fairy E is on the right side of the second black house.

Fairy F and Fairy G are like a group of three goblins, so Fairy F lives on the left of the first of the three black houses while Fairy G lives next door to her on the left side of the middle black house.

Now that we have found out where all the little fairies live, let us go to



Home of the seven fairies

the piano and see if we can find the little houses. Every day we should enjoy a real game of play with the fairies and goblins in the magic kingdom. We can think we are the postmen of fairyland and each morning we must take the fairies their letters, being sure to go to the right houses and careful not to forget any of our little friends.

Let us ask the fairies to play a game with us and see if we cannot learn to sing the note of each. We will knock first at Fairy C's door. We will choose that house of hers which is almost in the middle of the long white line, remembering that her houses are always found on the left-hand side of the group of two goblins' houses.

To knock at her door so that we may really hear her voice in answer, we must press down the little white piece very gently and firmly.

Listen! Do you hear her? It is Fairy C's voice. Try to sing the same sound exactly. Try a great many times, and then, when we think we know it quite well, we will run away to the end of the room and sing it again, coming back very quickly to the magic kingdom to see if we have remembered it rightly.

Fairy C likes to hear us say "This is Fairy C's voice," and she will always sing if we go to her house, C, and press the door very gently.

When we have played as long as we like with Fairy C, we may go to her next-door neighbor, Fairy D. Fairy D's voice is not quite like Fairy C's. We will press the door here, too, and listen to the answer, and then try and sing the same sound.

But we must not forget Fairy C's voice, so we will touch the door again and listen. Now we will go back to Fairy D, to be quite sure that we know each fairy's voice.

But there are more fairies, and so we go to Fairy E's house and learn her little "note," and then to Fairy F and Fairy G, until we reach Fairy C's second little house.

If we have a fairy concert every day we shall soon come to know all the beautiful fairy voices quite well.

LITTLE PROBLEMS FOR THE WISE

WHEN WAS THE WATCH RIGHT?

1. At noon on Monday Herbert asked his father what o'clock it was. His father told him that it was noon, and said that his watch was two minutes fast. On Wednesday morning Herbert again asked the time, and his father replied that the exact time was eight o'clock, but added that his watch was one minute slow. Herbert then told his father at what time his watch had been exactly right. Could you have done it?

ANSWER.—From noon on Monday to 8 o'clock on Wednesday morning is 44 hours. His father's watch, therefore, lost 3 minutes in 44 hours. But it was right when it had lost only 2 minutes, which it would do in two-thirds of 44 hours—that is, in 29 hours 20 minutes. This number of hours from noon on Monday would make it 5:20 on Tuesday afternoon.

HOW MANY DUCKS?

2. "How many ducks did you drive home?" asked Farmer Bell.

"There were two ducks in front of a duck, two ducks behind a duck, and a duck between two ducks," was the reply.

What was the number of ducks?

ANSWER.—Three.

WHAT VEHICLES WERE SENT?

3. An order had been received at a garage for automobiles for a party of fifty-nine. The manager had automobiles to seat nine and cabs to hold four, and he sent some of each, so that everyone had a seat and there was no seat vacant.

How did he do it?

ANSWER.—Try one automobile first. This will seat 9 and leave 50. There is not an exact number of 4's in 50, so that they could not be seated in cabs. Next try 2 automobiles. These will seat 18 and leave 41, which again cannot be seated in cabs. Next, 3 automobiles will seat 27 and leave 32. Now 8 cabs will seat exactly 32, so that the manager must have sent 3 automobiles and 8 cabs.

HOW DID THE SHEEP STAND?

4. "I saw an odd sight the other day," said Jones. "Two sheep were standing in a field, one looking due north and the other due south. How do you think that each could see the other without turning round?"

Can you give the answer?

ANSWER.—This is what is usually known as a "catch," and the answer is that, as they stood, they faced each other, one looking north and the other south.

THE CLOCK STRIKES TWELVE

5. John and his sister stood under the church tower and heard the clock strike six. John looked at his watch while it did so, and said to his sister: "It took 30 seconds to strike six." His sister replied: "Then how long would it take to strike 12?" John replied, "Sixty seconds, of course!" John was wrong. What is the correct answer?

ANSWER.—The clock would take sixty-six seconds to strike twelve. Between the first stroke and the sixth stroke there were five intervals of time, each interval being six seconds. Between the first and the twelfth stroke there were eleven intervals of time, each of six seconds, so that the clock would take sixty-six seconds to strike twelve.

HOW MANY EGGS?

6. If a hen and a half lays an egg and a half in a day and a half, how many eggs will one hen lay in six days?

ANSWER.—Four eggs. One hen would lay one egg in a day and s

half—that is, two eggs in three days, or four eggs in six days.

TWELVE EGGS IN BASIN

7. There are 12 boys, and on the table is a basin with 12 eggs. Each boy took one egg and there remained one egg in the basin. How was this?

ANSWER.—The last boy took the basin as well as the egg in it.

THE FARMER AND THE TRAMP

8. A tramp lies down for a nap at the side of a haystack, and hears the farmer approaching. He runs round and round the stack chased by the farmer. They start from opposite corners, the tramp taking forty seconds to run completely around and the farmer thirty seconds. How often must the farmer run around before catching the tramp?

ANSWER.—As the tramp runs round the stack in forty seconds, and the farmer in thirty seconds, the farmer can run round four times in the same time that the tramp takes to run round three times. This means that in four rounds run by the farmer he would gain one round upon the tramp; but, as the tramp had a start of only half a round, the farmer would overtake him after running only two rounds, which is the answer.

HOW MANY PERSONS WERE THEY?

9. Brown arrived at the inn to arrange lunch for his party. "How many of you are there?" asked the innkeeper. "Well, we represent father, mother, uncle, aunt, sister, brother, nephew, niece, and two cousins."

What was the fewest number that could be in the party?

ANSWER.—There were four in the party. The father and mother were brother and sister, one having a son and the other a daughter. The children were cousins, therefore, nephew and niece, and the father and mother were thus uncle and aunt.

HOW MANY STAMPS HAD THEY?

10. Three children—Jack, Frank, and Harry—divided some postage-stamps among them. Jack had half of them and one more; Frank had one more than half of those left; Harry had the remaining three. How many stamps were there?

ANSWER.—First let us find how many stamps were left when Jack had taken his share. Since Frank had one more than half, Harry must have had one less than half. You know that Harry had three, therefore four must have been half of the quantity that Harry and Frank divided. Half of eight is four so Frank had five. Now we must find how many Jack had. Jack's share was one more than half the total quantity and therefore the quantity divided by Frank and Harry must have been one less than half the total. Frank and Harry's share came to eight as we have seen and the half of the total quantity being one more than eight was nine. Jack had ten which is one more than half the total quantity and thus there were eighteen altogether.

WHOSE PORTRAIT IS IT?

11. One of the problems that have most puzzled our fathers and mothers is the old problem of a man looking at a portrait, saying: "Brothers and sisters have I none, but this man's father is my father's son." Whose portrait is it?

ANSWER.—If a man says that he has no brothers and sisters, his father would have only one son—himself. Thus, if what he says is put in simple language it is: "That man's father is myself." This means that the picture at which he looked was that of his own son.

DID GEORGE WALK ROUND THE MONKEY?

12. George was trying to tease the monkey which was seated on the top of a barrel-organ. But, although he

walked all round the barrel-organ, the monkey always turned so as to face the boy the whole time.

When the boy has walked round the organ, has he walked round the monkey?

ANSWER.—No. George never sees the monkey's back, which he clearly would do if he walked round the monkey.

HOW LONG WAS THE STRING?

13. A boy had two pieces of string, one of which was just twice as long as the other. He cut 6 inches off each piece, and then found that one was just three times as long as the other How long were they at first?

ANSWER.—To begin with, one piece of string was 12 inches long and the other piece 24 inches. After cutting 6 inches off of each the shorter piece was 6 inches long and the longer piece 18 inches long.

HOW FAST WAS THE HORSE WALKING?

14. I was walking along a country road steadily at the rate of four miles an hour. I saw a horse and cart going in the same direction, and when I saw them they were exactly 220 yards in front of me. I overtook them in 15 minutes. At what rate was the horse walking?

ANSWER.—In 15 minutes I had gone one mile and the horse 220 yards less than one mile. In one hour the horse would walk 880 yards less than four miles—that is three-and-one-half miles in one hour.

HOW MUCH DOES A BRICK WEIGH?

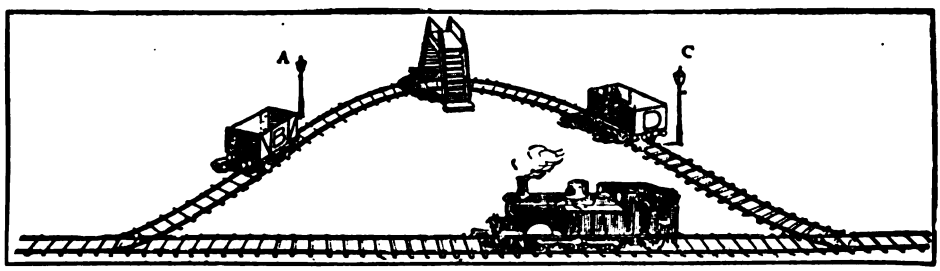
15. A brick weighs six pounds and half of its own weight. What is the weight of the brick?

ANSWER.—The brick weighed 12 pounds. The weight of each of the two halves is the same, so that if a brick weighs half of its own weight and 6 pounds, the 6 pounds must represent the other half.

HOW MUCH WATER WAS SPILLED?

16. A boat leaving a wreck had water to last 13 days, allowing each man one quart each day. After five days some water was spilled and one man died on the same day. The water then lasted just the expected time. How much water was spilled?

ANSWER.—The amount spilled would have served the man who died for 8 days, and this, at 1 quart each day, would have been 8 quarts.



How did the engineer change the cars?

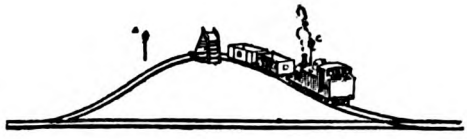
HOW DID THE ENGINEER DO IT?

17. The illustration represents a railway line with a short loop line extending from one part of the main line to another part of the main line. In the middle of the loop line is a bridge, under which a car can be pushed by the engine, but which is too low for the engine itself to pass through. On the left side of the loop line, near the lamp-post marked A, is a car marked B, and on the right side of the loop line, near the lamp-post marked C, is a car marked D. The engineer is told to take car B to the lamp-post C on the right side, and to

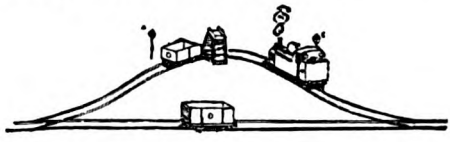
take car D to the lamp-post A on the left side, leaving them at these points, and then to bring his engine back to the main line. The main line extends further at each end than is seen in the picture.

How did he perform his task?

ANSWER.—The engine goes forward along the main line, backs up the left side of the branch line, and pushes car B through the bridge. Then the engine comes down the branch line, to the main line, along the main line to the right of the picture, then up the right side of the branch line, and pushes car D up to car B. At this stage the position is like this:



Then the engine pulls down both cars, brings them both to the middle portion of main line, where it leaves car B (which is the one farthest in front of it), and, going back again with car D, pushes it up the right side of the branch through the bridge. The position is then like this:



Now the locomotive comes back again to the main line, takes car B, and leaves it at the post C, finally coming down again along the main line, up the left side of the branch line, and pulls car D into its place. It can then return to the main line alone.

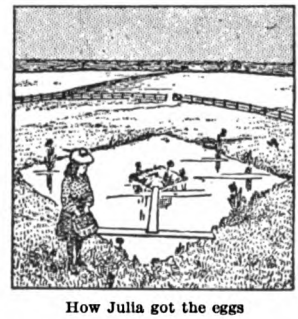
HOW DOES JULIA GET THE EGGS?

18. Dora and Julia gather the eggs on the farm. One morning Dora discovers that several eggs have been laid on a small square island in the middle of a square pond, and, having no plank long enough to reach across, she leaves the eggs alone.

Julia sees them the next morning, and, looking round for a means to reach the island, finds two planks, neither of which will quite reach from the edge of the pond to the island. But they are her only means of access to the eggs, and, placing them so that she can step across them, Julia reaches the island and takes the eggs home in her basket. How does Julia reach the island?

How does Julia get the eggs?

ANSWER.—Julia put the planks as shown in the picture, and thus reached the island.



How Julia got the eggs

RIDDLES

1. To what island should hungry people go?
2. Why is a policeman like an aeroplane?
3. Why are watches like grasshoppers?
4. What tree is nearest to the sea?
5. Why is charity like an umbrella?

6. Why is the eye like a very severe schoolmaster?

7. What flower is most likely to be found in the shop of a shoemaker?

8. Why is Sunday the strongest day?

9. What flower would you wish for when oppressed with woe?

10. Why are pen, ink and paper like fixed stars?

11. Why are hay and straw like spectacles?

12. Ten men's strength and ten men's length, and ten men cannot set it on end, yet one can carry it.

13. What is that which goes through the wood yet never touches the ground or the trees?

14. What tradesmen are always robbing themselves?

ANSWER.—(1) The Sandwich Isles; (2) Because he takes people up; (3) Because they move by springs; (4) The beech; (5) Because it is most useful when most widely extended; (6) He always has a pupil under the lash; (7) Lady's slipper; (8) Because the others are all week (weak) days; (9) Heartsease; (10) Because they are stationery (stationary); (11) Because they are forage (for age); (12) A rope twenty yards long; (13) The blast of a horn; (14) Butchers, because they are always stealing (steeling) their own knives and other tools.

THINGS DIFFICULT TO SAY

WE ALL know the curious sentence with many saws in it that we were asked to say when we first went to school: "Of all the saws that ever I saw I never saw a saw to saw like this saw was to saw." That is quite easy to say, but there are many other sentences with the same word or syllable or sound that are so hard to say, and especially to say several times in quick succession, that they have obtained the apt name of tongue-twisters. "Truly rural" seems quite a simple expression, and yet there are very few people who can say it quickly six times running without twisting it into something like toore-looral.

Here is a tongue-twister in the form of a verse:

Oliver Oglethorpe ogled an owl and oyster;
Did Oliver Oglethorpe ogle an owl and oyster?
If Oliver Oglethorpe ogled an owl and oyster,
Where are the owl and oyster Oliver Oglethorpe ogled?

Perhaps even more difficult to repeat than either of these is a verse in which the sound of q occurs in almost every word.

Quixote Quicksight quizzed a queerish quidbox;
Did Quixote Quicksight quiz a queerish quidbox?
If Quixote Quicksight quizzed a queerish quidbox,
Where's the queerish quidbox Quixote Quicksight quizzed?

The sound of c, too, mixed up with the sound of cr, is difficult to repeat over and over again in a sentence. Here is a sentence combining these sounds:

Captain Crackskull cracked a catchpoll's cockscomb;
Did Captain Crackskull crack a catchpoll's cockscomb?
If Captain Crackskull cracked a catchpoll's cockscomb,
Where's the catchpoll's cockscomb Captain Crackskull cracked?

A very good tongue-twister is the verse about the sea-shells:

She sells sea-shells on the sea-shore;

The shells she sells are sea-shells I'm sure.
So if she sells sea-shells on the sea-shore;
Then I'm sure she sells sea-shore shells.

Here is a prose tongue-twister which should be repeated very rapidly:

How much wood would a woodchuck chuck if a woodchuck could chuck wood? If a woodchuck could chuck wood, the wood that a woodchuck would chuck is the wood that a woodchuck could chuck, if the woodchuck that could chuck wood would chuck, or a woodchuck could chuck wood.

A shorter but scarcely less difficult tongue-twister is this sentence of only six words:

Seven Severn salmon swallowing several shrimps.

Here is a series of sentences that Dr. Moberly, headmaster of Winchester School, and afterwards Bishop of Salisbury, used to make his boys read, placing the emphasis on the right words. They are all perfectly correct but take a good deal of examination before the sense can be understood in each case:

I saw that C saw.
C saw that I saw.
I saw that that that C saw was so.
C saw that, that that that I saw was so.
I saw that, that that that that C saw was so.
C saw that that, that that that that I saw was so.
I saw that that, that that that that that C saw was so.

It is very amusing to try to repeat this:

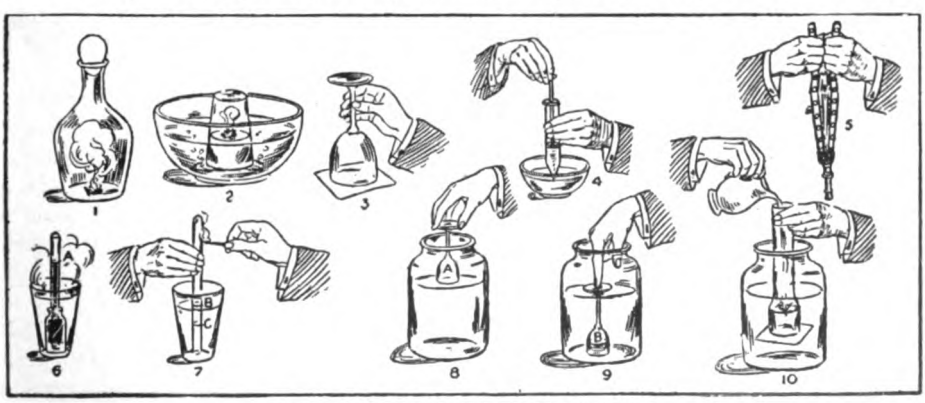
Mrs. Biggar had a baby. Which was the bigger? The baby was a little Biggar! Which was the bigger, Mrs. Biggar or the baby? Mr. Biggar was father Biggar! Mr. Biggar died; was the baby then bigger than Mrs. Biggar? No, for the baby was fatherless!

MYSTERY AND MAGIC

SIMPLE EXPERIMENTS WITH AIR AND WATER

WE can learn a great deal of science from the most familiar objects in our homes, and an interesting half-hour may be spent in performing simple experiments that will teach us much that we ought to know.

First of all, we can perform an experiment that will show us how the air, that is invisible and does not seem to have any weight, is actually pressing down upon us and upon



Easy experiments that can be tried in every home

everything on the earth's surface. We take a wide-necked bottle, and also prepare a hard-boiled egg to help us in our experiment by carefully removing all the shell.

Now we put into the bottle a piece of lighted paper, and, after a second or two, place the egg in the neck of the bottle as though it were the stopper. The egg will, of course, remain there just as if it were in an egg-cup. At least, that is what some of us would expect. But if we watch the hard-boiled egg we shall see, after a time, that it is gradually going down the neck of the bottle as though it were being sucked in. Then, suddenly, it will enter the bottle with a loud noise. What is the explanation of this? It is very simple. The burning paper heated and expanded the air in the bottle, and some of it was driven out through the opening at the neck. Then the egg was placed in the neck and the opening was stopped up. Presently the air in the bottle cooled, and, as it lost its heat, it contracted, or filled less space, so that there was a partial vacuum in the bottle, and the air outside pressing upon the egg drove it into the bottle. The report was caused by the outside air rushing in as soon as the falling of the egg opened the neck once more.

There is another simple experiment which shows clearly the pressure of the atmosphere. Take a basin of water, and on the surface of the water let a cork float. Now place on the cork a piece of lighted paper, and over these invert an empty glass, pressing it down gently into the water. Bubbles will be seen to come from under the glass. This is the air being driven out owing to the fact that the heat from the lighted paper has expanded the air, and the glass will not hold it all. A few moments after, the water is seen to rise in the tumbler. The cause of this is that when the paper is burned out the air cools again, and as it does not now fill the glass the pressure of the air on the surface of the water drives it up into the tumbler.

Still another experiment will prove that the air exercises a pressure, not only downwards, but upwards as well. We take a wine-glass, and fill it carefully up to the brim with water. Then take a thin sheet of paper, and place it on top, so that it touches both the surface of the water and the rim of the glass. Now, holding the paper carefully in position, we turn the glass of water upside down, and the water will remain in the glass apparently suspended. Of course, it is not really suspended, but the air is pressing it up into the glass. The air must not be allowed to get into the glass while we are inverting it, or the water will come out; and as any carelessness will result in an accident, it is always wise to perform the experiment over a basin.

If we should like another experiment to prove the downward pressure of the air, we can use our basin of water again, and take a small ear-syringe such as is found in every house. We fill it with water, and invert it with the point in the water in the basin. Now we press down the rod and empty the syringe. But directly we pull up the rod again the water rushes up and fills the syringe. The reason of this is that the pressure of the air all over the surface of the water in the basin drives the water up into the syringe.

An interesting experiment, this time with a pair of ordinary domestic bellows, proves that the pressure of the atmosphere is exerted, not only above and below, but sideways and in all directions. Having blown all the air out, we completely stop up the nozzle and the vent-hole with corks, and then, if the bellows are in proper

order and are air-tight, no boy will be able to open them, no matter in what position they may be held. The air outside pressing equally on all sides holds the bellows together.

All bodies, solids, liquids, and gases alike, when heated expand—that is, fill more space—and two simple experiments will show this clearly in the case of liquids and gases. We take a small bottle, fill it with some colored liquid, such as water in which a little coloring has been dropped, and cork it up. But we must see that the cork is pierced, and a piece of glass tube, open at both ends, inserted. Now, if we plunge the bottle into a vessel of warm water, as seen in picture 6, the colored liquid will be seen to rise in the tube to A. This is because the warm water in which the bottle was plunged has heated the liquid in the bottle, and caused it to expand and overflow into the tube.

To show that gases expand we must use a glass tube closed at one end. We take the tube, which is, of course, full of the gas that we call air, and put it into a tumbler of water, as shown in picture 7. The water rises to a certain point, B. Now we hold a lighted taper to the upper part of the glass tube, and, after a second or two, the water descends in the tube from B to C. This is because the heat expanded the air in the tube, and as it wanted more room drove some of the water out.

Another experiment with a wine-glass and a jar of water will show that gases, such as the atmosphere, possess the property of compressibility—that is, they can be pressed into smaller space. We take the wine-glass and invert it on the surface of the water. The glass is full of air, which occupies the whole of the space A in picture 8. Now we press the glass down to the bottom of the jar, and we see, as in picture 9, that some water has risen in the glass, and the air that formerly occupied the whole glass now fills only the space B. As we gradually lift the glass out of the jar, we see that the air expands and fills the glass as easily as it was compressed.

There is a simple experiment to show that liquids, like gases, exert a pressure equal in all directions. Take an ordinary lamp chimney and p'ace below the widest opening a piece of cardboard. Hold this against it and plunge the whole into a jar of water. Now remove the hand that held the cardboard, and it will be found to remain in position, the upward pressure of the water holding it against the glass. Now pour water gently into the lamp chimney from above; the card continues in position until the water in the glass reaches the level of the water in the jar. The pressure of water top and bottom being then equal the card will be displaced, and sink to the bottom of the jar by its own weight.

A TRICK TO PLAY WITH A BOOK

This is a trick of a really startling kind, which will puzzle even the wisest man if he does not know it.

You invite someone, the older and wiser the better, to take down any book he pleases from the bookshelves, to open it haphazard, and to choose a word in the first nine lines of any page, and not after the ninth word in the line. He is then to notice the number of the page, and multiply it by 10. To the product he is to add 25 and the number of the line. The result thus obtained is in turn to be multiplied by 10, and the number at which the word stands to be added to the product.

He is then to hand you the book, with a slip of paper on which are written the figures last obtained. After thinking for a few moments you

open the book and read out the word chosen.

To obtain this surprising result, all that you have to do is to subtract in your mind 250 from the amount given you on the slip of paper handed to you.

The last figure of the answer will give you the number at which the word stands in the line, the last but one the number of the line. and the remaining figures the number of the page.

Suppose, for instance, that the person choosing the word had happened to choose the fifth word in the ninth line of the eighty-fourth page. In such case the process would be as follows:

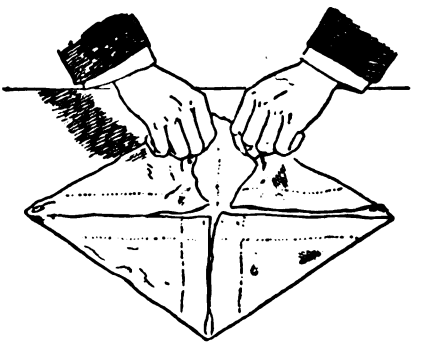
84× 10 = 840
840+ 25+9= 874
874× 10 =8740
8740+ 5 =8745
8745—250 =8495

And 8495, dissected as explained, gives 84, 9, 5, being the three clues necessary to the discovery of the word.

THE DISAPPEARING DIME

This is a capital trick. Two things only are wanted for it—a handkerchief spread out upon the table, and a dime laid in the middle of it. The corners of the handkerchief are folded down over the coin, and anyone is permitted to feel that it is still there. And yet, at the conjurer's command, it passes through handkerchief and table, and is found on the floor beneath. The handkerchief is shaken out, and proves to be empty. This trick is good enough to make quite a reputation for the youthful wizard, and yet it is simplicity itself—when you know it!

In the first place we must have two dimes in appearance as nearly alike as possible, and one of these we take an opportunity to drop quietly beforehand under the table at which we propose to perform the trick. The only other thing required is a little pellet of beeswax. This we must knead between the fingers till it is fairly soft, and then press, till needed in another sense, against the back part of our lowest vest button.



To perform the trick, take the wax off the button, and press it against one corner of the handkerchief which you are going to use. Then lay the handkerchief on the table squarely in front of you, with the waxed corner nearest to the right hand. Lay the dime on the center of the handkerchief, or better still, let somebody else do this, to prove that there is "no deception." Then fold down the corners of the handkerchief one by one over the coin, beginning with the waxed corner, and pressing this down a little, so as to make it adhere. This done we ask someone to make sure, by feeling through the handkerchief, that the coin is still there. Each person who does so presses the wax a little closer.

Now comes the exciting moment. "Now, ladies and gentlemen," you say, "I am going to make the dime pass right through the table, and be found upon the floor. If you will all be very quiet, perhaps you will hear it fall." They won't, but they may as well imagine that they do so.

We blow upon the center of the handkerchief saying, "Presto! Pass!"

Then, hooking the first and second fingers of each hand inside the nearer opening of the handkerchief, as shown in the picture, we draw the two corners smartly apart, one in each hand, and shake it out. The coin, adhering to the handkerchief, is drawn into the right hand. "Look under the table, and see whether it has gone through," you say, and while general attention is occupied by looking for and picking up the other coin, you will have ample opportunity to get rid of the one in the hand.

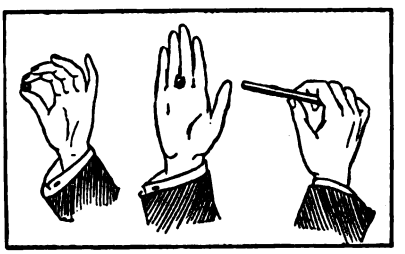
Of course we are not bound to make the coin pass "through the table." If we prefer it we may order it to pass under a candlestick, into a vase on the mantelpiece, or even into somebody's breast-pocket. All that is needful is to place the duplicate dime where we intend that it shall be found, and alter the command accordingly.

MAKING A BALL VANISH AND REAPPEAR

For the performance of this conjuring trick the only apparatus we need is a little ball, light in weight and rather smaller than a marble in size, and a small stick for a wand. We hold the ball up between the thumb and forefinger of our right hand, as shown in the first picture, so that all the spectators may see it clearly. Then we say that we shall place the ball in our left hand, and we proceed to do so; but instead of putting it in the left hand, we skillfully roll the little ball down the right hand, and fix it as shown in the second picture, so that it is supported between the second and third fingers. To do this quickly and successfully needs a little practice, but it is quite possible for any boy or girl to learn the trick in a very short time.

Now we close the left hand as if we were holding the ball in it. Then, still supporting the little ball between the second and third fingers of the right hand, we take up the wand, and, tapping on the knuckles of the closed left hand, we say, "Vanish, little ball!" and instantly we open the hand and show that the ball, which was supposed to be in it, has disappeared.

If we are skillful in performing the trick so far, we shall have no difficulty in continuing it, and, to the astonishment of the spectators, we shall call the little ball back from the inside of the wand. We continue to support the ball between the second and third fingers of the right hand, keeping the back of the hand towards the audience all the time, though, of course, without



How the ball is concealed

appearing to do this purposely. We take the wand in the right hand, as in the third picture, and, holding the other end with the left hand, we call to the ball to come forth from inside the wand. As we speak we work the ball in an instant from its hiding-place, and hold it up once again before the spectators, as in the first picture. Of course, in all such tricks as this we should practice well alone before attempting to give an exhibition before others.

THE BOY CONJURER'S JOKE WITH HIS AUDIENCE

At the end of a series of tricks it is often a source of great amusement to entertain the audience with what schoolboys call a "sell"—a practical joke in the disguise of a conjuring trick. The only apparatus needful is the pencil, and this you can manufacture for yourself. You have

merely to change an ordinary pencil in such a way as to make it look like an extraordinary one. For instance, you may paint it in three colors—red, blue, and yellow, successive rings of each color; or, for lack of paint, colored paper may be used—anything, in fact, to give it an unusual appearance.

Having performed a few genuine tricks, you produce the pencil and a blank sheet of paper, inviting the company to examine them. "Now, ladies and gentlemen," you remark, "you notice no doubt, that this is a rather peculiar-looking pencil. But its appearance is the least of its peculiarities. In point of fact, it is an electric pencil. At present, you see, it writes plain black like any other pencil." Here you make a few marks with it and proceed: "But if I electrify it a little, it will write red, blue, or yellow—in fact, any color, just as I please. What color will you have? Choose for yourselves." "Red," we will suppose is the reply. You gravely breathe upon the pencil, rub it upon your coat-sleeve, and proceed to write the word "red" in bold letters. "There it is, you see—red. If you had asked for blue or yellow, it would have been just the same." Which nobody can deny.

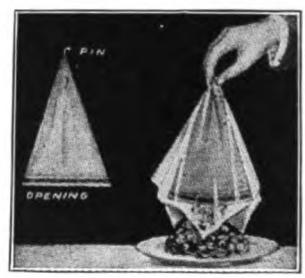
The success of the trick rests on the fact that the audience have been prepared, by seeing sundry surprising things, to expect something equally surprising. If the trick were offered offhand, without such preparation, some of the audience would probably see through the joke; but if it is led up to in a proper manner, they will hardly ever do so.

A GOOD CONJURING TRICK WITH NUTS

There is an excellent conjuring trick that can be performed with very little preparation or apparatus, and if it is practiced once or twice until skill is acquired, it will greatly mystify the spectators.

We hand round us for the inspection of the audience an empty dessert plate and a clean pocket-handkerchief. These can be handled by anyone who likes to prove that they have no secret pockets or recesses. We now place the empty plate on the table, spread over it the pocket-handkerchief, and then, after making a few mysterious passes with the hand or a wand, we raise the handkerchief and shake out of it upon the plate a number of sweetmeats or nuts.

This is the explanation of the trick. We make a small triangular bag, as shown in the first picture, by sewing



The trick bag

together two triangular pieces of linen or calico, and in the two hems on each side of the opening we sew straight pieces of watch-spring, taking care that in each case the spring goes the whole length of the hem. These springs, if flat, will close the opening of the bag, and keep it closed unless force is used to open it. A pin, bent to a hook, is put through the apex of the bag.

Nuts or sweetmeats are now placed in the bag, and the spring closes the mouth, so that when the bag is suspended they will not fall out. Having prepared the bag in this way, we hang it by the hooked pin on the side of the table that is away from the spectators, this being done, of course, in advance.

before they sit down, so that they know nothing about it.

After showing the empty plate to the audience, we place it on the table near the edge where the bag is suspended, and in spreading the handkerchief over it we see that part of it hangs over the edge of the table where the hooked pin is. Then in picking up the handkerchief we dexterously pick up with it the bag. The handkerchief falling around so as to hide the bag. The rest of the trick is simple. We shake the handkerchief with a few vigorous jerks and the impact of the nuts or sweets parts the springs, which are not very stiff, and allows the objects to fall out on the plate. The bag can then be skillfully dropped behind the table, which should, of course, have a thick cloth on it, reaching to the floor, to effectively hide the back. There are few conjuring tricks so easy to perform, and yet so surprising in their effects.

GAMES AND AMUSEMENTS

THE "ALICE IN WONDERLAND" TUB

ALL boys and girls know "Alice in Wonderland," and there is a good Alice game that we can play.

We prepare a shallow tub and decorate it, inside and out, with green muslin and pretty wreaths of ivy. Boys will easily put together a lattice made of wire, one, perhaps, with four large squares or oblongs; the outer circle should be of the same size as the tub. A very pretty cover is made when this lattice is decorated with greenery.

Then lovers of "Alice in Wonderland" collect as many as they can of the people in the book—white rabbits, the Mad Hatter, the Dormouse, Bill, the Lizard, and a host of other characters can easily be made up by clever boys and girls. They should be wrapped carefully in prettily tinted papers, and the packets should be tied with ribbons or tapes to match, leaving a long, trailing end. All the parcels should now be placed carefully in the tub, in such a way that the ends of ribbon can be drawn through one of the openings in the cover. Then, when pulled by a pair of eager hands, the ribbon brings out with it a package one longs to open. No packet must be opened, however, until the magic tub is empty.

Who will get the White Rabbit, the Black Kitten, or the dear, sleepy Dormouse? How delightful to find a lobster or a walrus, or one of the poor little oysters! A little pig may be in one parcel; a pepper-pot in the next. There is really no end to the number of delightful people and things that may be popped into the Lewis Carroll lucky tub. But the packages may only be *felt* by those who take possession of them, they are not to be opened until a signal is given, and even then they may be opened only privately—just a private peep.

Everybody then scampers to a seat and waits for more fun. A clever grown-up somebody takes a chair in the middle of the room and begins telling, quickly and cleverly, the story of "Alice in Wonderland," and when the moment comes for the dear, fussy White Rabbit to be mentioned a pause is made, the storyteller strikes a gong, and before sixty seconds have passed the child with the White Rabbit must have loosened the coverings that conceal him, run to the side of the storyteller, and hold him up for general observation, pronouncing his name. Sometime three or four people

must run at the same moment; what would the Mad Hatter, the March Hare, the Dormouse, and Alice do without the big teapot or the wonderful watch?

Each boy or girl who succeeds in getting to the center of the room at the right moment takes a chocolate from a box placed close to the story-teller, and returns to his or her place until wanted again. This time the concealing papers need not cover the treasure drawn from the lucky tub; it may be placed on the floor of the owner's feet, so that its beauties may be properly noted. Then, when the story comes to an end a big march past to music takes place, and a boy, wearing the Mad Hatter's Hat, makes a fine leader of the procession.

GAMES TO BE PLAYED IN THE NURSERY

HUNT THE SLIPPER

ALL the players but one—"cobblers," as they are called—sit on the floor in a circle a few inches apart. Then the customer comes and says: "Please, I want this old slipper mended. I will call for it in ten minutes."

She hands one of the cobblers an old slipper, and turns away. When she has counted up to ten, she comes back, but is told the slipper is not ready.

"I must have it," says the customer.

"Then you must find it," all the cobblers reply.

At that the search begins. Each cobbler passes the slipper on to his or her neighbor, hiding it from sight as much as possible; but should the seeker spy it and call out the name of the cobbler who has got it, that cobbler must take her place, and bring it to be mended again. The slipper must not stop in one place, but must keep passing round the circle, either one way or the other.

THE GARDEN GATE

The garden fence is made by all the players, except one, holding each other's hands, standing in a big ring. In the middle stands the single player, while the rest dance round her three times. Then they stand still while she sings:

"Open wide the garden gate, the garden gate, the garden gate,
Open wide the garden gate and let me through."

But the "fence," as the ring is called, only answers, as it dances round again:

"Get the key of the garden gate, the garden gate, the garden gate,
Get the key of the garden gate and let yourself through."

Then the poor prisoner cries:

"I've lost the key of the garden gate, so what am I to do?"

Still dancing, the others sing:

"Then you may stop, may stop all night within the gate,
Until you're strong enough, you know, to break a way through."

At this the prisoner runs between two of the boys and girls—the "palings" of the fence—and if, by pushing, she can make them unclasp hands, one of them takes her place in the middle and the game begins again.

HOLD FAST! LET GO!

You must listen to what is said in this game, and be careful to do exactly the opposite. Four players stand up, and each takes hold of one corner of a square sheet of paper or a handkerchief. A fifth player calls out: "Hold fast!" and anyone who does not let go will be out; while, if the order is "Let go!" those who *fail to hold fast* will be out. The orders must be given

rapidly, one after another, and someone is sure to make a mistake, but the last to do so, of course, is the winner.

PUSS IN THE CORNER

In this game all the children pretend to be mice, except one, who is the puss. "Puss" stands in the middle of the room. Each mouse stands in a corner. While there puss cannot touch them, but when they run across the room to change corners with one another she may capture any she can. No mouse should venture from a corner until she has made signs to another mouse with whom she would like to change houses, or she may find herself half-way across the room with no corner to run to. The mouse that is caught must take the place of puss.

BLIND MAN'S BUFF

Those who want to make a great noise will have a chance now. One player is taken into the middle of the room, where a handkerchief is tied over his eyes. He is then turned round three times and told to catch whom he can. The other players run to and fro, passing as near to him as they dare, while the blindman rushes in all directions, clutching at those who seem nearest. When he succeeds in catching someone, he must guess who it is, and, if correct, the person caught must be blindfolded in his place. If he cannot guess, he must leave go and try again.

WOLF

The "wolf" is a player who creeps away to one side of the nursery, and hides behind chairs and tables or boxes. The "sheep" all huddle up at one end of the room, and the shepherd stands at the other. Presently he calls out to the sheep to "come home, for the night is falling."

"We are afraid of the wolf," answer the sheep.

"The wolf is away!" cries the shepherd.

Then the sheep all run across. Out jumps the wolf and catches whom he can. The game lasts till there are no sheep left to be caught.

BINGO

The players join hands in a ring, with one of their number, who is called the "miller," in the center. Then all, still holding hands, dance round and sing:

"The miller's mill dog lay at the mill door,
And his name was little Bingo:
B with an I, I with an N, N with a G,
G with an O,
And his name was little Bingo."

Then as they stand still again the miller cries out "B" and points at one of the players in the ring, who must say "I," the next to her "N," and so on, until the little dog's name is spelled. The first player to say the wrong letter has to change places with the miller.

FEATHER AND FANS

A fluffy feather out of any cushion will do for this game, and if there are not enough fans to go round, stiff pieces of paper or thin card will do quite as well. Draw a line across the nursery floor, and let half the number of players be on one side, and half the number on the other. When all are ready, toss the feather into the air and keep it up with the fans. No players must leave their side of the line, but should do their best to stop the feather sailing across it. Those in whose country it falls at last lose the game. Of course the feather, while in flight, must not be touched.

GAMES TO PLAY BY THE FIRE

WORD-MAKING

NEAR the top of a slip of paper each player writes down a word given out by the leader of the company. Then all start to make a list below it of other words, spelled from the letters it contains—and these letters only. When the leader says that time is up (about ten minutes should be allowed), the lists are added up, and the player who has made the largest number of words is the winner. It is not necessary to choose a very long word, for it is surprising how many words may be made from the letters contained in any word of ordinary length. For example, from the word "animal" we can get: am, nail, main, lain, and so on.

MAGIC ANSWERS

This is a game in which two of the players form a plan between themselves to puzzle the rest. One of these two leaves the room, while his partner remains behind to choose with the rest of the company some object to be guessed.

The one outside is then recalled and questioned by his accomplice as to what this object is. Several things are touched. "Is it this?" "Is it this?" he is asked. To every inquiry he answers "No," until something is mentioned that has four legs, and as he and his friend have previously arranged that such an article shall not be referred to till just before the real object is named, he knows that the next question may be answered with a "Yes."

PROVERBS

While one of the players is out of the room, the rest think of a proverb. It should contain at least as many words as there are players.

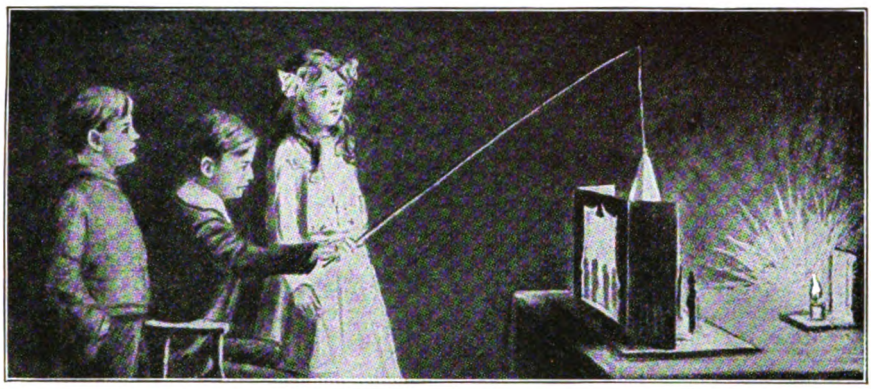
The boy or girl who has been sent out is now called back, and begins the game by asking the first in the row a question. This question may be of any kind, but the answer to it must contain the first word of the proverb. The next is then questioned, and replies with the second word, wrapped up, as it were, in the answer.

Supposing the proverb to be, "It is never too late to mend," and the first question is, "How many apples do you eat in a day?" the answer might be, "As it is not wise to eat too much of anything, there are some days when I don't eat apples at all." The word "it" is not easy to notice in this sentence. But it would be more difficult to hide the last word in the proverb.

Let us take as a question, for example, "Are you fond of reading?" The answer might be, "Yes; but I tore the pages of my favorite book, and must mend them before I can go on with the story." If you wish to puzzle the questioner you should not let your word begin or end the sentence.

GENERAL POST

All the players sit round the room in a large circle, and one, who is blindfold, stands in the middle. Each player takes the name of a town, and the leading player makes a list of these, from which he calls out now and then, thus: "The Post is going from Chicago to Denver," choosing "towns" on opposite sides of the circle. "Chicago" and "Denver" jump up and slip across to each other's seat, the blindman doing his best to catch one of them as they pass. When several towns have changed places, and the blindman has failed to make a prisoner, the leader cries out "General Post," when all must jump up and cross over to opposite sides. In the hurry and confusion the blindman is sure to catch someone, who takes his place while he becomes one of the towns.



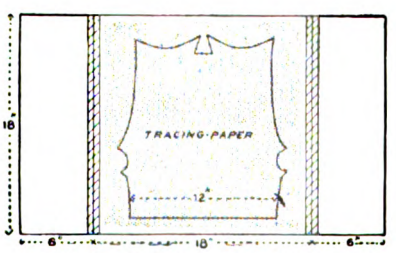
A LITTLE SHADOW THEATER

BY means of scissors, paste, cardboard, paper, and a piece of wood, any bright boy or girl can make an amusing toy that will provide plenty of fun for a Christmas or New Year party, and will be equally interesting for grown-ups and for children. The toy is a shadow puzzle game, and is made in this way. Take some stiff cardboard, and cut out two pieces 15 inches high by 6 inches wide. Then cut another piece 15 inches high and 18 inches wide, and from the center of this larger piece cut out a space about 12 inches high and 12 inches wide, so that what is left will look very much like the wings and curtain of a theater. Now take two strips of gummed paper, and fasten the two narrow pieces of card to the larger piece, one on each side, so that the paper will form hinges, and the side pieces can be turned at right angles to the middle card. Strips of linen pasted or gummed on to the card make even better hinges than the gummed paper.

To make this screen frame neat, cover one side of it with black paper—not the side on which the linen or paper strips are pasted. Then, turning the screen over, paste over the opening which we have cut out a piece of ordinary semi-transparent tracing paper. The paper should be as white as possible. The screen is now ready, and it may be put aside while we make the rest of the toy.

Cut out four figures in stiff cardboard, each about three inches high, and these should be, if possible, rather fantastic and humorous, as that will add to the fun of the game. Any kind of upright figures will do, and may be copied from books, but if there is any difficulty about drawing men, four

Little men for the shadow theater



The framework of the theater

upright pieces of card may be cut into any kind of irregular shapes, and will serve for the purpose of the game.

A piece of wood, 12 inches long by about 6 or 7 inches wide and ¾ of an inch thick, is wanted for a stand for these figures, and running the whole length of the board, cut six grooves at regular intervals, just wide and deep enough to hold the figures upright when they are placed in these grooves.

Now take some stiff paper and make four extinguishers, by rolling up the paper in the form of a cone, and cutting the opening evenly all round. Then sew a little ring in the top of each. The extinguishers should be about 4 inches high and 2 inches in diameter at the bottom.

Next get a thin stick about 2 or 2½ feet long, and in the end put a nail or drawing-pin, and to this fasten a straight piece of wire about 12 inches long with the end turned up slightly to form a hook. The wire should be stout enough to remain stiff and straight. All that is necessary now for the game is an ordinary candle in a candlestick.

Any number of people may play at puzzle shadows. Stand the screen on the table, with the wings folded at right angles, as shown in the picture, and put a lighted candle some distance at the back of it. One who does not take part in the game acts as master of ceremonies. He puts the wooden stand between the screen and the candle, and then places each of the four figures in a groove.

All lights in the room except the candle are turned out. The first player now takes his place before the screen, and he must on no account look round or over it to see what is behind. Hooking the wire holder into the ring of one of the extinguishers, he lifts this over the top of the screen, and guided only by the shadows of the figures and extinguisher on the paper front of the screen, he tries to put the extinguisher over one of the figures. So long as the shadow of the extinguisher is above the shadows of the figures it may be moved about in any direction, but directly it touches or begins to cover the shadow of a figure it must be let down at once. The holder is gently unhooked, and another extinguisher is lifted over the screen in the same way. This is done until the player has tried to cover all the figures by using all four extinguishers. He is then allowed to go behind the screen, and see how he has succeeded.

Great is his astonishment when he finds, as is usually the case, that instead of extinguishing all four figures, he has set down the extinguishers at quite long distances from them. Nothing is more deceiving than the shadows on the screen, and as each player takes his turn the candle or the figures are moved so that the shadows do not appear in the same places as before. The player who covers most figures wins, or, if it is desired to prolong the game, points may be given for each figure covered, and be added up at the close.

It is essential that the master of ceremonies gives no indication either by word or by the expression of his face as to how a player is succeeding while he is endeavoring to cover the figures; and it is important, too, that the candle be kept well back, so that the extinguishers, as they are moved about, cannot get into the flame and catch fire.

YOU MUSTN'T LAUGH!

All sit in a row round the fire and look solemn. Then the first player says: "Haw-haw!" which is repeated all down the line, one after another. Those who cannot do this without laughing afterwards are declared out, and the game begins again.

AMUSING GAMES FOR HALLOWEEN

HALLOWEEN, or All Hallows' Eve, is a festival that has long been observed, particularly in Scotland, and although many of the customs associated with the season are superstitious, yet there are also some interesting games which boys and girls have played for generations on Halloween, or the last night in October.

Ducking for apples in a tub of water — Cutting down the apple — The apples captured from the water

Some of these historic games are illustrated on this page. One of the most popular is that of ducking for apples. A large tub or bath is nearly filled with water, and a number of apples are set floating on the water. The boys and girls then gather round, and take it in turn to duck their heads into the water, trying at each duck to seize an apple in their teeth.

Sometimes the apples chosen are provided with stalks, and sometimes apples without stalks are selected. The greatest fun is to have some of each kind. Of course, those with stalks are captured first, and then the excitement increases. Small apples can be sucked up into the mouth, but the larger ones have to be chased to the bottom or side of the bath, and there seized with the teeth.

Another game is to suspend an apple from the ceiling or chandelier by a string, and for the boys and girls then to take it in turns to try to cut the string. They have to be blindfolded, and are placed some distance from the apple. Then they take three steps forward, scissors in hand, and make a cutting motion where they think the string is. It is great fun to see the many amusing and fruitless attempts that are made before anyone succeeds in cutting down the apple.

These pictures show a boy and girl playing the Halloween game of dropping a fork to pick up an apple

Still another game with apples is to place several of them in a tub or bath of water, and to put this near the back of a chair. Then the boys and girls take it in turn to stand or kneel on the chair, and to drop a kitchen fork into the tub, trying to spear an apple. If the player succeeds, the apple is his. Sometimes the fork is held by the handle in the mouth, and allowed to drop from there into the tub. This makes it harder to spike the apples. We must, of course, be careful not to overbalance the chair.

Instead of the tub being nearly full of water and having apples floating in it, it is sometimes left dry, and in it are placed an apple, a potato, a carrot, and a turnip. The boys and girls then drop the fork and see which they can manage to secure. The apple is the most sought after, and the turnip is regarded as the least desirable.

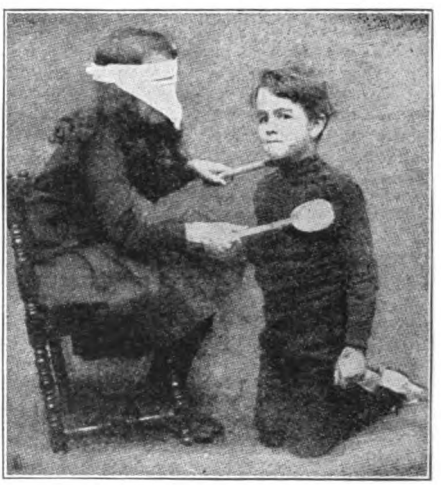
In addition to these games, there are many other customs practiced on All Hallows' Eve which are interesting as being survivals of a past age. For instance, nuts are placed in the fire, and according to the order and the manner in which they crack or jump out, so certain things are imagined as to what will happen in the future. Very few people believe in such foolish superstitions nowadays, but there is much amusement in watching the nuts and seeing how they happen to fall and which crack first.

Literature is full of references to Halloween. The most famous is perhaps Burns's poem, beginning "Among the bonnie winding banks." Goldsmith, in his "Vicar of Wakefield," refers to the custom of cracking nuts on Halloween.

GOOD GAMES FOR A CHRISTMAS PARTY

To make a Christmas party a thorough success there is nothing like having plenty of variety in the games. There is no chance then of the boys and girls getting tired because some of the games are more or less alike.

A very good game for a large or small party is that of "guessing with the wooden spoons." One of the party—a girl, for instance—is blindfolded, and sits upon a chair. She is then given two large wooden spoons, such as are in common use in every kitchen. One after another the other boys and girls come up to the blindfolded sitter and stand or kneel before her, and she has to guess who each one is by simply feeling him or her with the wooden spoons, as shown in the picture on this page.



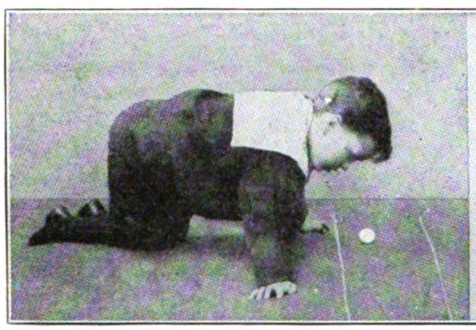
Guessing with the wooden spoons

The task is very much more difficult than it looks, and there is great fun as the spoons go over the face and body in the attempt of the blindfolded player to discover the identity of the other. It is not easy for the one who is being touched with the spoons to abstain from laughing, especially when all the other players are equally amused.

Of course, any outburst of laughter when the spoons are going over our face would disclose our identity, so we must keep perfect silence. When

anyone's identity is guessed, he has to be blindfolded and must take the spoons. We must be careful when using the spoons to touch another player with them quite lightly, so as not to hurt him; and any player who wears glasses should remove them before going to be felt with the spoons.

Another good game for a Christmas party is that of blowing the egg. Two pieces of cotton or tape are stretched across the carpet in a straight line about two feet apart. Then an ordinary hens' egg—not too large—which has been prepared beforehand by being blown—that is, having the contents removed without cracking the shell—is laid exactly midway between the



Blowing the egg across the line

Fanning the egg with a paper fan

tape lines. A girl player then makes a little paper fan out of half a sheet of notepaper, and kneels down on one side of the tapes, and a boy kneels down on the other. The girl then has to try to fan the egg-shell across the tape on the boy's side, and he has to try to blow the shell back across the tape on the girl's side. The one who first drives the egg across the partner's line three times wins the contest. Nothing must be used by the girl but the paper fan or her hand; and the boy, on his part, must simply blow with his mouth. If more convenient, a large dining-table may be used instead of the floor.

A CHRISTMAS TREE FOR THE BIRDS

Christmas would not be Christmas without a Christmas-tree. But have you ever thought when you have been enjoying yourself, that the winter, which brings lots of fun for all of us, is a very uncomfortable time for the poor things who do not have warm homes?

Perhaps, on some cold morning, you have looked out of your window, and have watched the birds flying about among the bare branches of the trees in the garden, searching the ground in the hope that some kind person has thrown out a few crumbs for them?

Have you not sometimes wished there was a Santa Claus to bring a tree full of good things for the birds? Perhaps it never occurred to you that *you* might be the birds' Santa Claus? Well, we are going to see how to make a Christmas-tree for those poor little mites.

First, we must get a small tree that can be put into a pot. Probably we shall find one in the garden, and will be allowed to dig it up. If not, we can buy one about Christmas-time for a few cents.

When we have our tree planted in a large flower-pot, we must get some small baskets—the tiny ones that sweets are sold in will do splendidly—and tie these baskets to the branches of

the tree. We can put all sorts of things into these baskets—bread-crumbs, nuts, little pieces of crust or toast from the breakfast table, or some of the seeds that are given to tame birds and little pieces of suet.

A Christmas tree for the birds

We can make our Christmas-tree look very pretty with some bright pieces of cloth and ribbon, or colored paper made into little bags to hold bread-crumbs, and then, when it is finished, we must put it out in the garden or on the window-ledge of our own room. At first the birds will not understand, because nobody has ever taken the trouble to make a Christmas-tree for them before, and perhaps they will think it is some sort of trap. But presently some of the bravest ones will come. Then we shall see them perch on the branches, and look round in every direction to see if there is any danger.

We can watch them through the window, and they will not be frightened if we do not move. As long as we keep quite still, they will not think we are going to hurt them. In a little time the birds will put their tiny heads in the baskets, and give a little twitter of delight when they find the good things there. Other birds will be watching them from the trees, and when these see that the braver ones have not been hurt, they too will come. When the tree has been out a little while, we shall see perhaps forty or fifty birds of all sorts fluttering round it.

When they have eaten everything, we can refill the baskets.

GARDEN GAMES

TOM Tiddler's Ground is a good game when there are at least three players. One is told off to be Tom Tiddler, and his ground is the lawn, or the path, or any other part of the garden that may be specially marked off. Tom Tiddler gets on to his ground, and, shutting his eyes as he stands, pretends to be asleep, and the other players venture upon the ground, singing:

> Here I am on Tom Tiddler's ground,
> Picking up gold and silver.

As Tom Tiddler makes no sign of being awake, the other players go farther and farther on to his ground, and then suddenly Tom Tiddler makes a dash, and tries to touch one of the others. If he succeeds, the one touched becomes Tom Tiddler. If he does not, and both of the other players get quite safely off his ground, he must continue to be Tom Tiddler.

GAMES OF TOUCH

Cross Touch is a good game for three players, and provides plenty of exciting play and healthy exercise. One player is "He," and has to call out the name of another player, and then to run after him.

The third player tries to run between the hunter and the hunted, and if he succeeds in doing so, "He," has to run after him and try to touch him. But if the second player manages to run between the others, then he draws

off "He" after himself. The more frequently the player runs between hunter and hunted, the more exciting and varied the game becomes.

Touch Wood is another game that can be played by three players. One is "He," and runs after the others, trying to touch either of them. But if a player touches wood—a tree-trunk, or fence, or wooden shed, or anything of that kind—he cannot be touched by "He." Of course, those who are being pursued must not touch wood too often, nor must they remain touching it for very long, or the game will get slow. What "He" has to do is to try to drive them where there is no wood to touch.

FOLLOW MY LEADER

If the garden is a large one, Follow My Leader can be played with a good deal of fun. One is chosen as leader, and wherever he leads the others must follow, whatever he does they must do, even to a motion of the arm, or leg, or head. The first one to fail in following the leader loses the game. Of course, the leader must be careful to do nothing that will mean danger for a younger player, and he must be very careful not to go too near flower-beds, or to do anything that will result in damage to flowers.

FIELD GOLF

We are going to play golf in a new way, which is quite simple, but very good fun. Choose a starting-point in a large field and dig there a very small hole. One hundred steps away, in a straight line from this, we make another hole in the ground. Then, at the end of another hundred steps, another hole, and so on until we have gone round the field and are back at the starting-point. These holes mark our golf-course. Each player is armed with a club-ended stick and a small, hard indiarubber ball. The game is to strike these balls round the course, knocking them into each hole as it is reached, and the one who does this and gets round to the starting point with the fewest strokes wins. Each player, of course, only hits his own ball. The starting-place should also be used as the last hole.

TUG OF WAR

A strong, long rope is laid on the ground across a chalk line. The players are then divided into two parties, one side taking up the rope on one side of the line and the other the opposite side. At a given signal they pull against each other with might and main, and the side that draws the enemy over the line are the victors.

FLAGS

A long straight line is chalked on the grass, and the party of players is divided into two equal numbers, or sides. Each side then goes into its own "country," the line stretching between them. Every player must have a small United States flag to stick down in the turf or lay down on the grass, a few yards inside his line, a handkerchief, a cap, or a scarf; these may be the "flags." At a given signal one side rushes across the line to try to capture the enemy's flags. Those who succeed must be allowed to return to their country, but any caught before securing a flag are prisoners. It is then the other side's turn to cross the line, and their prisoners (if any) must help to capture the lost flags and those belonging to the enemy. No player must take more than one flag at each attack, and the side that is first to lose its flags is defeated.

BOUNCE ABOUT

Two players, with two marbles, play this game. The larger the marbles the better. One boy throws his marble down. If his companion can

hit it with his own, he wins 10 marks, and has the right to try again, aiming from the spot at which his marble stops. He may keep on till he misses, when the other player takes a turn. A certain number should be fixed upon —say, 100—and the player whose marks reach this first will be the winner. Sometimes this game is played with smooth pebbles.

CATCH-BALL

Any number of players can join in this game. It simply consists of tossing the ball from one to another, but it may be made more exciting if no special plan is followed as to whom the ball is to be thrown next. This keeps everyone on the alert, and a very good trick is to look at some other player than the one you intend to throw to. This nearly always leads to a slip on the part of the catcher.

STEEPLECHASE

This is hard work as well as good play. Before starting, a certain point is fixed upon at some distance, with fences and ditches and hedges and brooks in between. Then the word "Off!" is given, and the players race away to see who can get there first. In such a race it is not certain that the fastest runner will win, for the boy who knows how to get over a difficulty stands a good chance.

THE TRAVELER AND THE WOLVES

The smallest boy or the slowest runner is the traveler, and the traveler has to get to his journey's end without being caught. The rest of the players are the wolves. Before setting out on his journey, the traveler is given as many tennis-balls as there are wolves, and, of course, there should not be more than four or five, or he will have too much to carry. When he has got some distance away, the wolves roar out that they are coming, and the race begins. When the traveler finds a wolf overtaking him, he throws out one of the balls, which the wolf must secure before he can take up the race again. Of course, the traveler's object should be to throw the ball in a way that will lead the wolf from the direct path. Thus, he should never throw it in front, or the swifter runner will pass him to secure it, and then merely wait for him to come up. Knowing what the traveler is going to do, the wolves will probably spread out a little to either side in the hope of stopping the balls more quickly. Therefore, the traveler should do his best to find out where the nearest wolf is, and the more skill he shows in managing the balls the greater will be his chance of escape. Above all, he should not throw them away too soon.

If the chances against him are very great at the start, he might be provided with more balls than there are wolves. Of course, a distant spot should be chosen as a goal.

LEAP-BALL

This game, which can be played out of doors, is also suitable for a large, clear room. We attach an ordinary indiarubber or tennis ball to a piece of string. The best way to do this is to put the ball in a net and fix the string to the net. Then one player takes the other end of the string and swings the ball round and round on the ground in a circle. The other players stand round in a circle, and as the ball comes round and round each player must jump so that the ball goes under his feet and does not touch him. Any player who is touched must take his place in the center and have a turn at swinging the ball while the others jump.

CROSS-BALL

Cross-ball should be played by two players standing two or three yards

apart. They should start with two balls, and should each toss at the same time so that the balls pass in mid-air. It requires quickness of sight and hand to keep this up, but a little practice will make it easy, and by-and-by a third ball may be added, when the effect is very pretty.

Chestnuts, or any small round objects that are not heavy, or too hard, are better for this game than balls, as they are quickly and easily handled. If the players count aloud as they throw, their actions will become more regular, and slips less frequent.

FIVES

This is a game for two or four players. Draw on a flat brick wall a long chalk line, three feet six inches above the ground, and another one along the ground, ten feet from the foot of the wall. Then across each end of this last line, which should be about ten feet in length, draw another at right angles to it, and connecting it with the wall. These lines are to show where the ball is to bounce.

The players divide into two parties —we will call them A and B. A throws the ball against the wall, where it must strike above the chalk line, and when, on springing back, it bounces from the ground, B must strike it with his open hand, sending it against the wall again. Then comes A's turn to hit it on the bounce, and this is kept up, turn by turn, until someone makes a slip.

If the ball strikes beneath the chalk line, or rebounds *outside* the ground-lines, the side that did *not* make this mistake counts 1 to itself. The side that first reaches 12 or 24 marks wins, but any number may be chosen as the players decide.

DRIVING A BLINDFOLD TEAM

A very good game to play in a field or playground, or large schoolroom, is that of driving a blindfold team in and out of a line of bottles or tins. We place the bottles in a row, as shown in the picture, taking care that there is room between any two bottles for two boys or girls to walk abreast. Then, having blindfolded the horses, the driver ties the reins to their arms, and drives them in and out of the bottles, turning the horses alternately to the right and to the left, until they have passed through the whole line.

For every bottle that is knocked over or touched by the horses in their passage, one mark is counted against the team. When one team has driven over the course, another takes a turn, and so on, until all the teams have been through. Then the team that has the lowest score wins the game.

A successful blindfold team

The reins are tied on the outer arms of the team, and the only guidance the blindfolded horses have as to where they shall go, and how they shall avoid knocking over the bottles, is by the pull to right or left given by the driver. It is therefore essential for success in a race that the driver should keep a clear head, and give the necessary directions to his team with skill and care.

EGG HAT

The caps of the players are laid in a row on the ground at the foot of a wall; they should be tilted a little, so as to make it easier to toss a ball into

them. The players then stand in a row at a line about eight steps away, and one of them pitches the ball at the hats. The moment this is done they all scatter, except the boy who owns the hat it has fallen into.

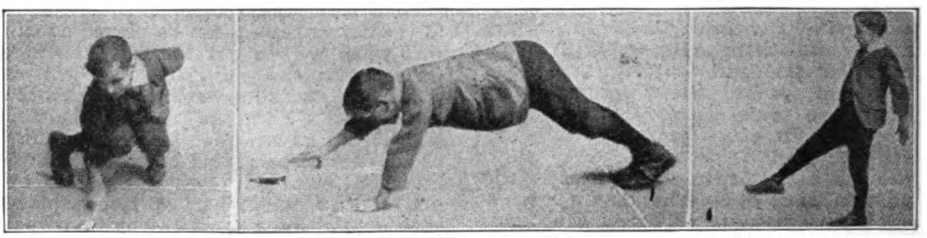
He must take out the ball as quickly as possible and throw it at one of the other players. If it hits him this boy must, in turn, pitch the ball at the hats.

But if the thrower misses him, a small pebble is placed in his cap as a bad mark, and when any player has missed so often that the number of pebbles in his cap equal the number of players, he is made to stand at a short distance while the rest throw the ball at him, each in turn. The game then starts afresh.

A pebble should also be added for every time a player fails to toss the ball into a hat.

overbalance in the course of pushing the matchbox forward we have to start again. Success depends almost entirely upon knack and balance learned in practice, for short, stout boys are sometimes more successful than tall, thin boys. We should bend as low as possible on the right side, keeping the left shoulder and arm well back to counterbalance the forward weight of the right arm.

A somewhat similar trick is shown in the second picture. In this case we bend forward on all fours, and then, raising the right hand, push the matchbox as far as we are able. Here, again, practice makes perfect, and it is astonishing how far we can push the box after we have tried several times. In this trick, knack does not count for so much; we need strength to support ourselves upon the left arm while reaching forth to push the matchbox.



PUSHING THE BOX THE ARM AND LEG STRETCH KICKING THE BOX

THE MATCHBOX ON THE LAWN

Here are three amusing tricks needing no apparatus other than an empty safety matchbox. We make a line upon the ground either with chalk or by stretching a piece of string across; or we can use as the toe-line any line that there may be upon the linoleum or on the carpet. Then stooping down into the position shown in the first picture, and placing the right hand under the knee, we push the matchbox as far as we possibly can, keeping our toes all the time to the marking-line, and taking care not to lose our balance. Of course, if we Some prefer to close up the left hand when resting upon it, but keeping the hand open and resting upon the palm gives a better support.

In the third trick we have to stretch with our leg and foot. Some line is marked or decided upon on the floor or lawn, and we toe this line. Then we stretch out with our foot as the boy in the picture is doing, and place the matchbox on the ground just beyond where the foot reached. Now, again toeing the line, we take great care not to overbalance, and, stretching the right foot and leg forward, try to kick over the box.

If we succeed we mark the spot by a match, and put the box still farther away. Then, again, we try to kick it over, and so long as we succeed we continue putting it farther and farther from the toe-line, until at last we mark the limit of distance to which we can reach. Other players then take a turn, and it is very exciting to watch the efforts and see who can kick farthest.

GAMES TO PLAY WHEN OUT WALKING

TO MAKE a walk thoroughly interesting and enjoyable, even though it be over an old and familiar route, is quite easy. We merely want to arrange some simple and amusing games that can be played as we walk, and, of course, those games that will draw out our powers of observation and encourage us to take note of the things that we see during our walk are the best.

COUNTING THE DOGS

One such game is that of counting dogs. One player takes one side of the road and all the streets leading out of it, and the other player takes the other side of the road and all the turnings out of it. Then, as they walk along, they watch their own particular side and see how many dogs they can count. Every ordinary dog counts one point, but a black dog counts two, and for every perfectly white dog seen one point is deducted. Any player who sees a Dalmatian or coach dog wins—the game, no matter how many points others have made.

This game can, of course, be developed, and general objects taken instead of dogs. Thus, a perambulator, a truck, a two-wheeled cart, a policeman, a bicycle could score one point; a soldier, a sailor, a tricycle, or a four-wheeled van could score two; and for a rider on horseback, a motor-cycle, or a flock of pigeons, a mark could be deducted, and so on. Players can always make their own rules before setting out, the rules varying, of course, according to the district where the walk is to be taken.

On country roads sheep and cattle would be very common, and in city streets vans, carts, and automobiles would appear in great numbers. Of course, more than two players can play these games. If there are four or five players, sides can be formed.

GUESSING THE COLOR OF TAILS

Another good, quiet game that can be played while out walking is that of guessing the color of horses' tails. Every horse that we see coming towards us gives an opportunity for guessing. We must guess while the horse is some distance away, and the one who is proved to be right when the horse comes near scores a point.

A game for the city or town is to look out for the names of tradesmen, printed up over their shop-fronts, that form ordinary words. Names that are trades, for instance, might be selected, and one looks at one side and the other at the other side of the street. Every name over a shop that is the name of a trade would mean one point. Such words as Baker, Butcher, Brewer, Taylor, and so on, would score. Of course, other kinds of words could be selected—names of animals, like Bull and Lamb.

Another game for a walk in a shopping thoroughfare is to select some number, like 6, and every time it occurs over a shop-front, on a cart, or on any other similarly conspicuous place, for the players to say six. This would happen whenever such numbers as 6, 16, 26, and so on, appeared. But if the number appears twice running, as in 66, 166, and 266, the players must

say six, six. In the numbers 61 to 69 the players must say six one, six two, and so on. Any failure on a player's part to keep to these rules means one mark against him, and the player wins who has the fewest such marks to his credit.

THE GAME OF ADJECTIVES

Of course, many games that are played in the living-room can be played equally well when out walking. There is, for instance, the old game of adjectives. Somebody starts by saying, "My mother had a cat." Then the players take it in turn to put an adjective before cat. First of all, it must be a word beginning with A, as an artful cat, an awkward cat, an apt cat, and so on. When at last a player cannot think of a word beginning with A that has not already been used, he has a point scored against him. If nobody can think of a fresh word beginning with A, then B is taken—a bad cat, a blessed cat, a beautiful cat, and so on. The one who has fewest points scored against him for failure to think of an adjective wins the game. This is a good game to play when a considerable number of companions are out walking together in the country.

THE GAME OF WHERE IS IT

One boy gives a description of an interesting place visited, a scene in history, or reads one of the descriptions given below, and the game is to guess the place or incident described.

THE CITY OF CROWDED STREETS

How hot it is! The sun's rays beat down from a cloudless sky so fiercely that our eyes turn with relief to the broad river speeding by eastwards. Low down on the banks are crowds of people with brown skins, and here and there some wearing white turbans. They are bathing in the water and crowding up and down stone steps, leading to curious little buildings. Can these be little temples? Farther along the banks steamers are busy loading indigo and saltpeter to take away. All around we hear strange speech, and we look in vain for clean streets. How narrow and crooked they appear!

Answer: Benares, India.

THE CITY WITH THE GOLDEN DOME

It is winter, and we are in a big city where the streets are deeply covered with snow; there is no sound of vehicles, only the tinkling of sleigh-bells and voices to break the silence. The shops have signboards and objects hung outside to tell what they sell, because many of the people cannot read, and certainly we cannot recognize the letters. We follow the way the sleighs take and come to a cathedral with a golden dome and wide granite pillars at the entrance. In front is a river—but a river frozen over. The ice will bear carriages; it will stay there till the spring, and when it melts there will be a religious ceremony and a blessing of the waters.

Answer: St. Petersburg.

TREES FOR EUROPE'S SHIPS

We are in a country covered with thick forest, so dense that it is only with great difficulty we can make a way through it. Hark! That must be men sawing wood and chopping down trees, and a young man, wearing a white helmet, is directing them, and —why, yes; those big animals working so hard are elephants. They are piling up the big logs with their strong trunks as though they were handling little sticks, and others are dragging along the chained trunks. The man tells us they are clearing a way for a railway through the forest, and the teak-trees they are cutting down are to be used

for building ships. He says there are nearly twenty thousand square miles of tropical forest, and that some tigers and leopards have been seen near. Do you know what country we are in?

Answer: Upper Burma.

WHERE THE COCOA-NUTS GROW

We seem to be on an island in the midst of a big sea, for there is water everywhere, except here and there where small islands are scattered about. We are standing on a beautiful white sandy shore, dotted with lovely colored shells. It is only one o'clock in the day, yet, when we look at our little pocket compass and then at the sun in the sky, we find the sun is to the north of us.

Away inland the ground rises in terraces, forming a kind of amphitheater, up to the highest point in the middle of the island, which looks about 8000 feet above the sea, and reminds us of a broken-down volcano. We turn up one of the gorges, and see palm-trees with cocoa-nuts growing on them, great tree-ferns, sugar-canes, and oranges. We meet some contented-looking, brown-skinned natives, who tell us in broken French that they are going to dive for oysters to get mother-of-pearl from the shells that they find.

Answer: Tahiti, Society Islands, Pacific Ocean.

WHAT SCENE IN HISTORY?

We are in a tent in a meadow by the bank of a river. In the tent are gathered a number of men armed after the fashion of the Middle Ages, and through the opening of the tent we see troops standing. The men in the tent look angry and determined, and bend threatening looks on one who is the center of attention, and wears a crown. The foremost man of the group is urging him to put his signature to a document spread out on a table before him. At last he consents, sets his seal on a lump of wax and throws himself on the ground in a rage. Who is he, and what is the deed he has been forced to do by others and now so regrets?

Answer: King John signing Magna Charta.

THE LANDING OF A BRAVE BAND

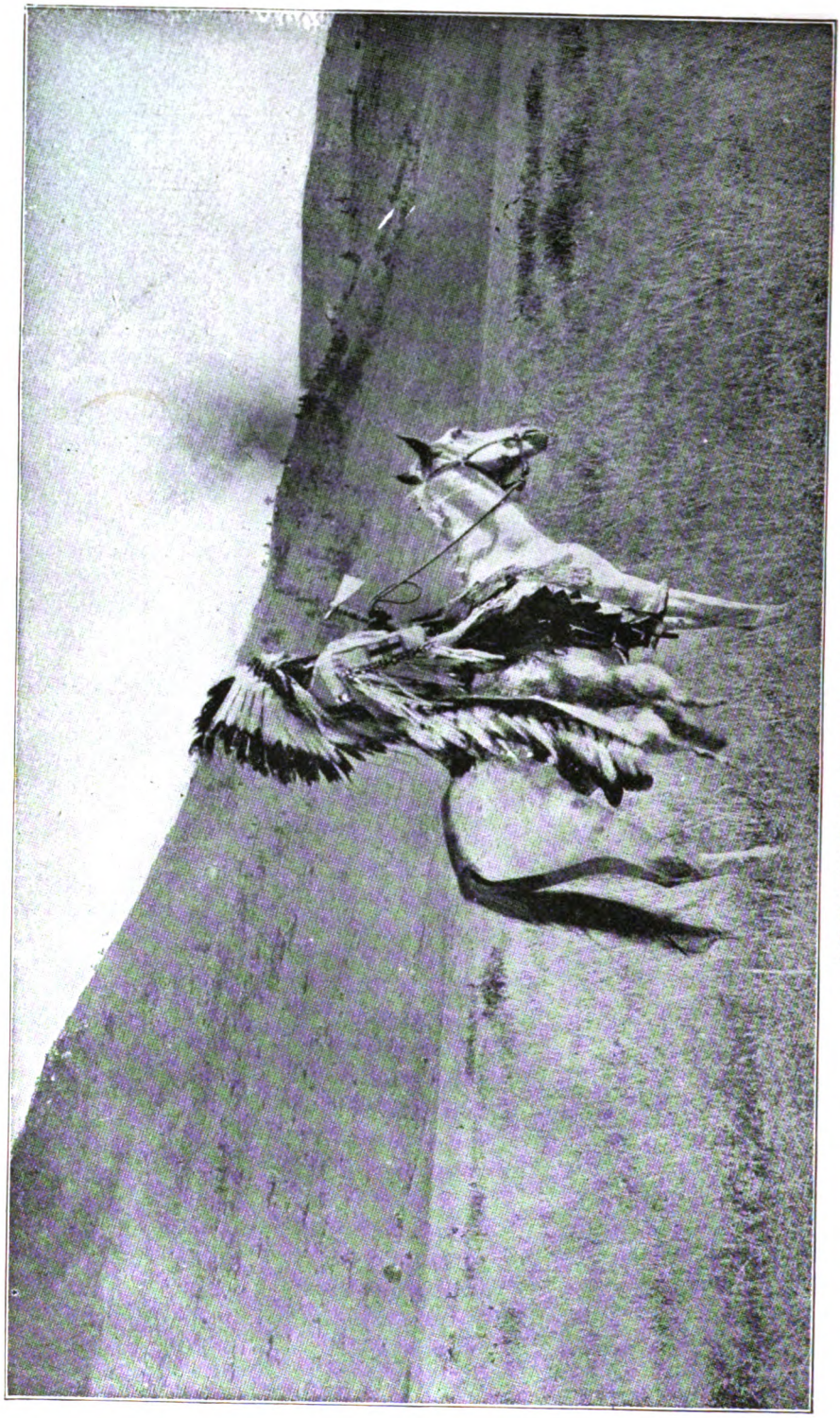
We are on the coast of a wild, uncultivated country. Behind the bare rock on which we stand, forest stretches far inland. Off the shore is a small bark at anchor, and from it we watch men, women and children landing. They are dressed in plain garments, and seem to belong to the artisan class. They are evidently weary, yet how brave they must be to cross that wild sea in their small boat of 180 tons, and land with their little children on an unknown shore. Who are they and why have they come here, where there is neither shelter nor food for them?

Answer: Landing of the Pilgrim Fathers with their wives and children from the *Mayflower*.

AN INTERRUPTED GAME OF BOWLS

We have before us a bowling green, where men are intent on their play. Near by stands a man gazing out to sea across the harbor. He pays no attention to the game, but stands shading his eyes from the sun. Suddenly he sees something, for he turns, and striding up to one of the players, eagerly points out to him the beacon being lighted close by. But to his surprise the player goes on with his game of bowls, coolly remarking: "There is plenty of time to finish the game and beat the Spaniards too." Yet, all around, people are gazing out across the harbor, or making hurried preparations. What incident is this?

Answer: Sir Francis Drake warned of the approach of the Spanish Armada while at bowls.



A WARRIOR OF THE VANISHING RACE OF RED MEN

THINGS FOR BOYS TO DO

I am going east | I have not gone far | I have gone far | Gone five days' journey

TELLING A STORY WITH BRANCHES AND TWIGS

THE SILENT MESSAGES OF THE RED MAN

ALL readers of Fenimore Cooper's Indian stories know how clever the red men were at following a trail and reading the silent messages which their friends had left for them, and which would pass unnoticed by most of us.

This was, of course, in the last century, before civilization had spread into the far west, but even now he is very clever at giving and receiving silent messages, and some of the signs which he uses are well worth

Stones, twigs, grass, and tree signs

knowing. They will be particularly useful to Boy Scouts and all who love to spend their spare time in the open country.

The red man can make use of any common object of the countryside to convey his message. If he wants to tell his friend who follows an hour or a day later which way he has gone, the road is marked by a series of stones every here and there, one being placed on another. Or, if there are no stones, a twig from a bush or tree is stuck in the ground at intervals, or a bunch of grass is knotted as shown in the picture, or a mark made on a tree-trunk. If the friend following is to turn to the right or left, the direction is indicated by a third stone or by the direction in which a twig is laid or the knotted grass is twisted.

Sometimes a more permanent and substantial sign is fixed up. A stick or small branch of a tree is stuck in the ground slanting-wise, and according as its free end points north or south, east or west, so an observer could know which way the traveler had gone. If the one fixing up the sign wished to indicate how far he was going, he would place another smaller stick upright in the ground against the slanting stick. If it was near the fixed end it meant he had not gone far, but if it was near the free end of the slanting branch the traveler had gone far. By placing a number of uprights along the slanting stick, the red man would show how many days' journey he had gone. Two sticks crossed means "this path is not to be followed." A circle drawn on the ground, with a stone or another small circle inside, means, "I have gone home." An arrow drawn in the dust of a road shows the route to follow.

But not only does the Indian use such methods of leaving information behind. He has a vast code of signs

The camp is here | I am lost | Good news | Summons to meet

TALKING TO DISTANT FRIENDS BY SMOKE SIGNALS

by which he can talk to one of his own or a friendly tribe without speaking an audible word. Night is indicated by closing the eyes and inclining the head as though it were on a pillow. Day is shown by joining the thumb and forefinger, describing a circle with them, and pointing from east to west. Hunger is shown by sawing across the breast with the hand; scratching the chest means fire; the earth is indicated by pointing to the ground; to speak of a house or tent, the red man places his two hands together to form the shape of a gable roof; when he wants his friend to look at something he points to his eye and then at the distant object. "I understand" is shown by making a circle with the thumb and forefinger, and passing it away from the mouth. Wherever possible an action was indicated by imitating the operation, as in drinking, eating, burying something, and so on. The smoke of fires was formerly much used for sending messages to friends a long distance away in a level country like the prairie. One or more fires were lighted, and the rising columns of smoke conveyed the message according to an arranged code. Thus one column of smoke would simply indicate the position of the camp, two fires with two rising columns of smoke would be a cry of distress, meaning "I am lost," three columns means "I have good news to tell," four would be a summons to a council of chiefs, and so on. It is not necessary, of course, to copy the actual signs used by the Indians. We can take their idea, and adapt the signs to the particular country in which we happen to be.

MEASURING DISTANCE BY SOUND

Most boys and girls have a watch nowadays, and it is a very interesting occupation for the country to measure distances by means of sound. Sound travels at the rate of about 1142 feet in a second, which is equal to about a mile in four and a half seconds, or thirteen miles a minute. If, then, we have a watch with a second hand, and we can see the cause of a sound, we can measure how far it is from where we are standing to the place where the sound first arose.

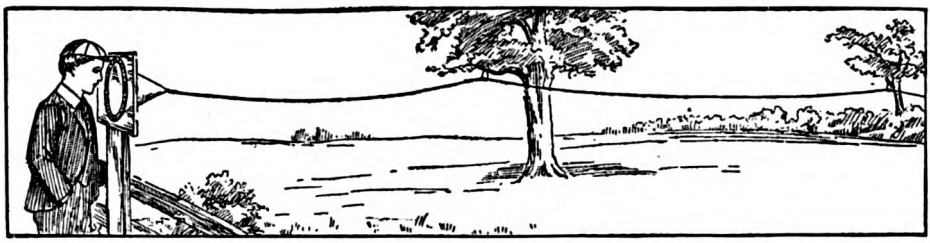
If we are near a place where artillery practice firing their guns, we shall be able to measure the distance of the guns from where we happen to be by noticing the puff of the smoke, which indicates that the gun has been fired, and then watching the second hand of our watch and seeing how many seconds pass before we hear the report of the guns.

In this way we may also measure the distance of a thunder-cloud. We see the flash of lightning, and by means of our watch are able to tell how many seconds pass between the flash and the thunder-clap, which is, of course, the report of the flash or electric spark. Having this time and knowing the rate at which the sound travels, a very simple sum in arithmetic will give us the distance away of the thunder-cloud. Many other sounds will enable us to measure distances in the same way.

If we are on a broad river in a row boat on a dark night, we can, by striking the water with the flat of the oar and listening for the echo from the bank, judge roughly of our distance from shore. We can also tell which bank we are nearer to, for the nearest bank will send back the echo first.

AN EASY WAY TO MAKE A TELEPHONE

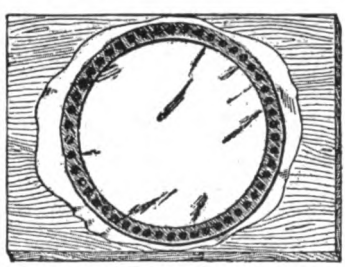
To make a real telephone is a somewhat difficult task, but we can make a good telephone which will enable us to speak, in favorable conditions, up to a quarter of a mile away with very simple materials.



The materials we shall require include two boards about 14 inches long, 10 inches wide, and about half an inch thick. We should be able to get such boards by breaking up an empty box, and sawing up two of the boards to these sizes. Then we cut a circular hole about eight inches across in the middle of each board. We have first to mark the holes to be cut out.

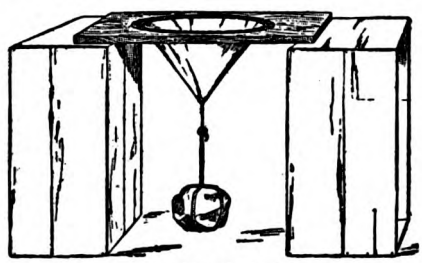
This is easily done by getting a plate about eight inches across, laying it face downwards in the middle of the board, and marking the wood round the edge of the plate with a lead-pencil. To cut out the holes properly we should have a keyhole saw or a fret-saw; but if we do not have either of these tools we can make shift by making holes with a gimlet right round the circle we have made. The holes should be as close together as we can get them. Then by using our chisel we can cut out the circular hole. Having done this, the boards are ready, and we can put them aside until we have the other parts of our telephone ready.

2. Button and wire



1. Fixing the bladder

Now we want two fresh beef-bladders. We blow them up hard, tie the necks with string, and put them aside for a few days to stretch. We must not leave them so long that they get dry. When they have stretched, we cut off the necks and soak the bladders in warm water until they are white and pliable. Then we put them over the holes in the boards we have prepared, putting the outside of the bladders to the wood. They should be put on evenly without creases, and not stretched in one direction more than in another direction.



3. Stretching the bladder

Now we take a thin leather band, or some pieces of leather which we can make into a thin leather band, and tack it all round one of the holes above the bladder as seen in picture 1. This will attach the bladder securely to the board. The tacks should have big heads, and should be driven well home. Old boot-tongues will do nicely for the leather. We cut these up into strips about half an inch wide for the purpose. We fix the two bladders in this way to the two boards in which we have cut the holes. Then the edges of the bladder outside the leather strips should be cut away.

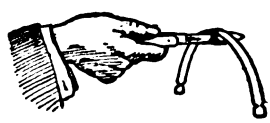
Now take a button and attach a thin wire to it by passing the wire through two of the holes in the button, as seen in picture 2, twisting it so that it will not come out. Make a hole right in the middle of the bladder and put this wire through. Then hang something heavy—a weight of about 7 pounds, or a large stone—to the other end of the wire, as seen in picture 3, putting the board in some position so that the weight can pull down the bladder. We treat both bladders in this way, and leave them in the sun until the bladders are dry and hard.

All that remains to be done now is to fix up the two boards and bladders at a distance apart, and connect them by fixing a wire to the two wires attached to the buttons. This wire should be fine copper or tinned iron wire. The wires may need to be supported if the distance is great. This can be done by hanging loops of string to the branches of trees, or to any posts that may be in the way. Then we may speak from either end, and the words should be heard distinctly at the other end. We should speak close to the bladder. When we wish to "ring up" the other end, we tap the bladder at our end with a pencil.

SIMPLE KITES AND HOW TO MAKE THEM

There are many different kinds of kites. Some are very simple, and these we shall see how to make in this article.

The ordinary kite is made with very simple materials, and its manufacture costs very little indeed. First, we require the half of a hoop. The size of the hoop depends upon the size of kite we are going to make, or, rather, the size of kite that we shall have will depend upon the size of hoop that we use. A hoop from a butter-cask will do very well for a small kite, and any grocer will be glad to give us one if we ask him. We do not use the whole hoop, but only a piece a little smaller than half of it. We choose the best for this purpose, and cut away the remainder. Then we thin the half-hoop with a pocket-knife, taking care not to take off enough to weaken it much. We must thin it equally all round, and we should test it to see that we have not made it lighter at one side than at another. The way to test it is simple. Take a piece of string and put it round the outside of the half-hoop, then cut it off to the exact length of the half-hoop. Double the string then, and again put it round the half-hoop as far as it will go from one end. Make a notch with the penknife where the end of the doubled string comes. Then balance the half-hoop on the edge of the knife-blade at this point, as seen in picture 1. If the half-hoop hangs

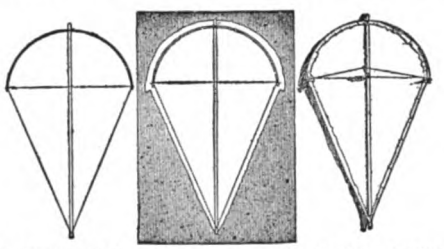


1. Testing the top

2. Top with notches

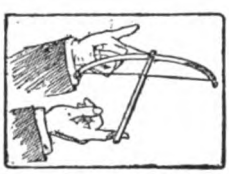
evenly, and does not hang down at one end more than at the other, it is all right; but, if one end hangs down more than the other, we must shave a little more wood from the heavier end, so as to make it the same weight as the other end. When we have got the half-hoop thinned properly and balanced, we make a notch at each side of each end, close to the end, as seen in picture 2, and put it aside till the backbone of the kite is ready. We require for the backbone a length of wood that will be strong and light. A piece of thin cane will do nicely if it is rather stiff.

But a long slip of wood—say, from 24 to 30 inches long—will do about as well. We thin and smooth this slip, and then tie it to the notch in the center of the half-hoop, so as to leave 1 inch sticking up beyond the top of the half-hoop. Picture 3 shows the kite at a later stage, but shows also the position of the hoop and the backbone. Now tie a thin, strong string to one end of the half-hoop, or top, as we shall now call it, at one of the end notches, pass the string once round the backbone, and the other end tie to the notch in the opposite end of the top.



3. Frame of kite 4. Cutting the paper 5. Strut in position

Balance the whole by placing one end of the backbone on one forefinger, and the other end of the backbone on the forefinger of the other hand. We can then see if the top swings heavier at one side than at the other. If one side is heavier, we move the backbone along the string a little bit, until we find from the swing that it is right in the middle between the two ends of the top. Picture 6 shows how we test the balance.



6. Testing the balance

Having done this, we join each end of the top with string to the bottom end of the backbone, where we put a notch or a hole to receive the string. The kite now looks like picture 3. All the strings should be fairly tight.

We now get a large sheet of thin strong paper. A sheet of a large newspaper would do, but imitation parchment paper, if we can get it, is stronger and better. The paper must be large enough to cover the entire kite from top to bottom and from side to side. If the only paper we can get is in too small sheets, we can make one sheet large enough by pasting two or more pieces together at their edges.

We place the kite on the top of the paper, on a table or on the floor, and, with a pencil, draw a line round the kite, about one inch outside the hoop top, and ½-inch outside the string sides, as seen in picture 4. Paste or gum the edges of the paper, and fold it over, and stick it down. Turn it over carefully, and stick on two or three patches on the back, thereby sticking the backbone to the covering paper and strengthening it. The kite is made, and we may prepare to fly it.

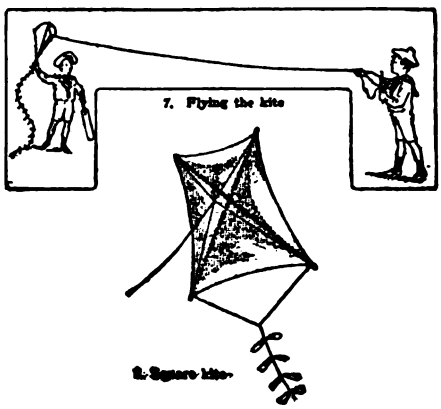
Tie a string at the back from side to side, from one end of the top to the other end of the top. Take a piece of wood about 4 inches long, and, having cut a notch in each end of it, fit it between this string and the backbone with one end on each. From the back, the kite will now look like picture 5.

Tie a string from top to bottom of the backbone in front. This is the bridle. It must be slack, so that the kite will fly properly.

Tie another piece of string to the lower end of the backbone and let it hang loose—say, about 5 yards long. This is the tail. Make some loops in the tail right down, 2 feet apart, and put in tufts of paper, and then pull the loops tight. These tufts are streamers, and make the kite look well when we fly it.

The kite is now ready for the field. We take it out when the wind is fairly

strong. We should have a ball of string, or more than one ball, wound upon a stick. Tie the end of this string to the bridle so that the kite hangs horizontal when suspended, and tie a piece of turf to the end tail. One boy takes the kite by the bottom end, leaving the tail lying free. Another boy takes the ball of string to which the kite is tied, and goes away about 10 yards in the direction from which the wind is blowing. Both stand and wait for a breeze. Then, as the boy with the kite cries "Go!" he throws the kite violently forward into the air, and his friend runs his best. Then, if it has all been properly done, the kite soars aloft steadily in the wind, and



7. Flying the kite

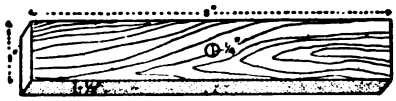
8. Square kite

the string can be let out carefully and gradually. If the kite does not rise, the tail may be too heavy, and some of the turf must be taken off. If it wobbles, or rushes from side to side, the tail may be too light, and a heavier piece of turf must be put on.

That is, perhaps, the simplest form of kite. A square kite is another very simple shape, and is shown in picture 8. From this picture, and from the description of how to make the kite we have seen, we can make a square kite without further instructions.

A SIMPLE FLYING MACHINE

Most of us know that the propeller of a steamship, as it revolves, drives the ship through the water. This is because the slope of the blades drives the water away from the ship behind, and this pushes the ship forward. A very simple flying machine can be made on the same principle, and when we have made it we shall perhaps understand better how it is that a ship is driven



1. Wood for the flying machine

forward by the revolution of its propellers.

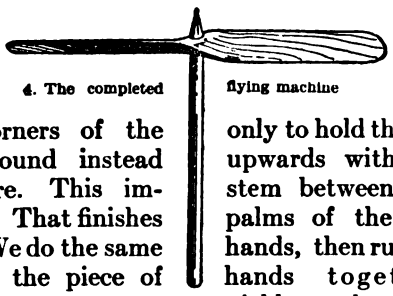
First, we get a piece of wood about 5 inches long, 1 inch wide, and half an inch thick, as illustrated in picture 1. Soft wood, such as is used for firewood, will do well enough, so that we may simply take a piece of firewood if we can find a piece large enough each way. Right in the middle of it and on the flat side we bore a hole about a quarter of an inch in diameter. We can do this with a gimlet, and we must do it carefully and slowly so that we do not split the wood. The hole is made right through from side to side of the wood. Picture 1 indicates the position and size of the hole. A little distance from this hole at one side we cut away the corner until we get it down to look like picture 2. The end of the piece that we have cut will be almost triangular in shape.

2. Cutting one of the wings

3. The wings after cutting

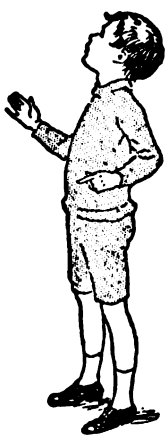
Now we begin at the opposite corner at the same end of the wood, and cut it away also until we have one end of

the wood almost up to the hole in the form of a slanting blade, but very thin. Its resemblance to the blade of a ship's propeller begins to be seen, and it will look something like the right end of picture 3. We make the corners of the part we have cut round instead of leaving them square. This improves the appearance. That finishes one end of the blade. We do the same with the other end of the piece of wood, except that we cut away, not the same corners as we have cut away in the first end, but the opposite corners. Then we shall have the two ends cut away to the form of thin blades, but the slope of the one will be opposite from that of the other, as shown in picture 3. Our toy is almost complete.



4. The completed flying machine

We have now to fix a stem firmly into the center hole. A butcher's meat skewer, if made of wood, will do for the stem, or a wooden penholder, or even a thin lead pencil. The stem may be any length from 6 to 9 inches. We may glue the stem into the hole, but it is not really necessary. It will be sufficient if we push it in firmly, but not so far as to split the blades. When we have the stem fixed, we have only to hold the toy upwards with the stem between the palms of the two hands, then rub the hands together quickly, and release the machine as we make it spin. It should soar aloft as high as the roof of a house if we have done it properly. If we have not done it properly, we may find that the toy strikes the ground at once instead of flying. If so we may know that we have spun it in the wrong direction before releasing it, and we can do better at the next attempt. A little practice will enable us to make it soar high every time.



5. Flying the machine

THE PLEASURE OF A LITTLE GARDEN

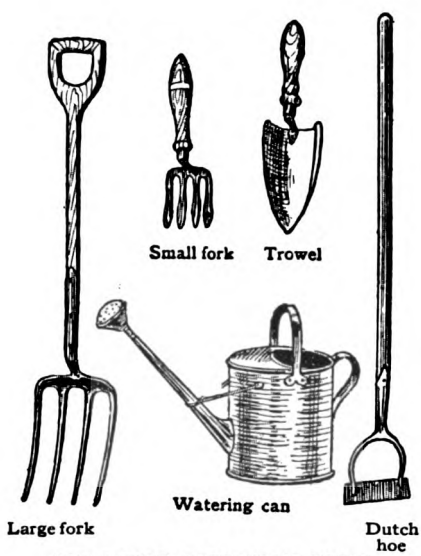
THE spring is a capital time in which to start a little garden of our own—the earlier the better, but the middle of April will do if we have not thought of it before.

Gardening is a splendid hobby, because it gives us plenty to do and plenty to think about, and plenty of wonderfully interesting things to find out. When we make a garden and plant it, we set ourselves the task—and it is a very pleasant one—of looking after the welfare and health and comfort of all sorts of plants, many of which have different tastes and requirements; and it is one of the experiments we must always be making to see if we are giving each plant just what it most wants. Some like a great deal of sunshine, some like the shady places; some like a dry position, some a moist one; some like to grow among the stones, some stretch up, and need arches or posts to support them.

After we have acquired our plot of ground, we need a supply of tools before we can transform it into a beautiful garden; and we ought to get tools as large as we can comfortably handle. This applies especially to such an important tool as the spade. Other tools that will be needed will be

a hoe; and many people find what is called a "Dutch" hoe the most convenient to use for weeding.

A rake will be necessary to smooth the surface and to clear up the rubbish. Something smaller than the spade will be needed for planting, and for this purpose a trowel is useful; but where it is a question of digging holes in ground where many bulbs may lie hidden, a trowel may damage them, so that a little four-pronged fork in a handle of the same length as that of the trowel is very useful; and, if we cannot have both, the little fork will do all that the trowel does, and should be the one we should choose.



THE LITTLE GARDENER'S TOOLS

A large fork set in a handle the same length as the spade is a most useful tool, and can often be used for digging, especially round about plants already established, as it is not so likely to injure their roots as the spade. A watering-can is necessary, and one the rose of which takes off and on should be bought, as quite as often we need to water through the spout as to sprinkle the water through the rose. A wheelbarrow is useful to have, either to bring soil or to cart away weeds, leaves, and other rubbish; or, failing that, a strong basket will take its place.

The first work in the garden plot will be to dig it as deeply as you possibly can—that is one of the reasons why it is necessary to have a spade that really can do some good work, because deep digging is of the utmost importance. You can understand that the deeper you work the soil the better it is for the roots of your plants, and in well-worked soil these go creeping out in all directions to find food and drink wherewith to build up and sustain healthy and sturdy leaves and stems and flowers.

The middle of April is not too late to sow seeds of many plants that will flower during the summer and autumn. Plants that flower so quickly as this are called annuals. They do not come up year after year in the garden, as some plants do, and live for many seasons. No; annuals are the shortest lived of all plants, and you must sow seeds afresh each year. But an annual accomplishes a great deal in its little life. You sow the seed; the seedling appears, grows quickly into a little plant; the buds appear, and open out into beautiful flowers. Then they fade, and the seed-vessels grow; and when the seed has fully ripened the plant dies. And all within the year!

Among the prettiest and brightest of annuals are larkspurs, poppies and nasturtiums. The sweetest smelling is, perhaps, the mignonette, and one that is interesting for its quaint seed-vessels is known as love-in-a-mist.

The great point to remember in seed sowing is to sow as thinly as possible, and however thinly we sow we shall have to draw out many of the seedling plants when they appear, but we can think about that later on; though any boy or girl who already

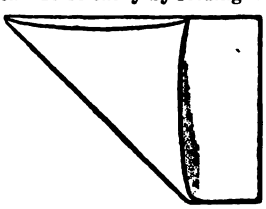
has a garden, and has reared his seedlings, may at once set about thinning them, as it cannot well be done too soon.

Some of the seeds may be sown in lines, especially where we need a row to serve as an edging; or, again, they may be sown in circles. These, when they grow up, make nice patches. There are a few rules always to be borne in mind when sowing seeds in the open ground. The soil must not be so wet that it is sticky and hangs together in lumps, neither should it be so dry that it is like powder. Second, the seed must not be buried too deeply; and third, it must be sown thinly.

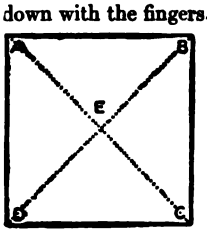
If the soil is too wet, it is better to wait for a few days until wind and sun have partially dried it, and if it is too dry it must be watered.

HOW TO MAKE A PAPER BOX

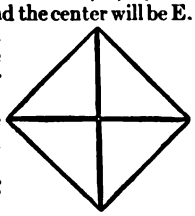
ANY clever boy or girl can make a neat paper box suitable for bonbons, valentines or party favors. First, take a piece of paper, which should not be too thin or too soft. A piece the size of this page or a little smaller will do nicely. Now make the paper exactly square. You can do so easily by folding it over as shown here. Cut off the part where the folded upper piece does not cover the lower piece, and what remains will be exactly square.



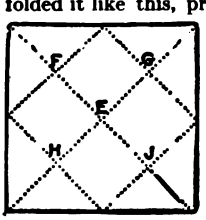
You have already folded the paper diagonally—that is, from corner to corner. Make a good crease by pressing it with the fingers at the fold, then open it out and hold it diagonally from the other corners, and press the fold well down with the fingers. The paper will now be square and creased as in this picture.



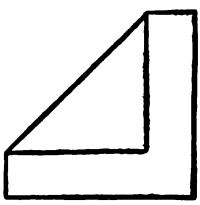
Notice the letters on the picture, so that you can understand easily what to do. So that we may understand what follows more easily, we shall call the four corners A, B, C, and D, and the center will be E. Now fold all the corners in carefully so as to touch the center, and make the paper as here shown.



The paper will now be in the form of a square, but a much smaller square than formerly. Having folded it like this, press it down well at the folds so as to crease it plainly.

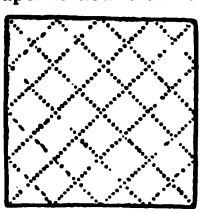


You will now have four more creases, and when you open out the paper again it will be creased where the dotted lines are in the next illustration. The other letters—F, G, H, J—mark where the creases cross. Fold the corner A over to the spot J, as seen in this illustration.



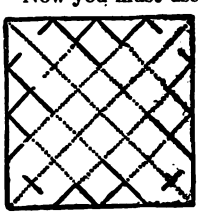
That will make another crease. Now make another crease by folding the corner B over to H; another by folding the corner C over to F; and another by folding the corner D over to G.

We still want four more creases. Make them by folding A over to F, B over to G, C over to J, and D over to H. The paper is now creased as shown here.

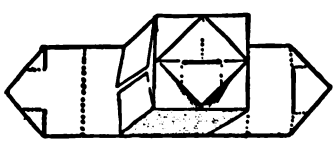


Every one of these creases is necessary to make the final box, although, as the paper is now, it is not easy to see why all these marks are wanted. But we shall see presently the use of all the creases.

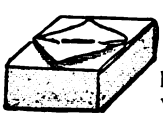
Now you must use scissors. Cut along where there are black lines instead of dotted lines in the next picture.



You now have a paper which does not look very like a box. But you have only to fold it up in the proper way, and you will see that it is. Fold over the corner at D like this: and slip it into the slit near B. Now fold in the flap at the side, and you have it like this:



Fold over the corner at C, and slip it into the slit at A, and the box is now finished. If you have made it properly, it will be very neat and perfectly regular.



A MAGIC LANTERN FOR PICTURE POSTCARDS

FOR winter evenings nothing is more interesting than a good magic lantern. Unfortunately, the lanterns that are bought at the shops have this disadvantage: they will show only slides that have been painted or photographed on glass, and these slides cost money; and even if the owner of the magic lantern has a good many of them, he soon gets tired of showing the same pictures over and over again.

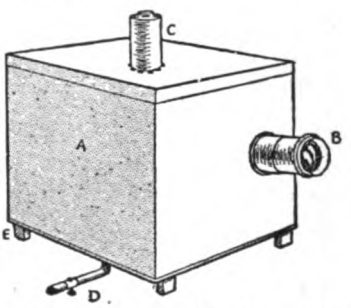
Most boys have wished they could have a lantern that would show any sort of picture on the screen, and so we are going to tell them how they can easily make one for themselves.

The magic lantern here described can be made out of an old biscuit-tin. It does not require glass slides, but it

1. Magic lantern showing picture postcards

will throw on the white sheet in natural colors a big picture of anything that is put into it. When we have made it we can put picture postcards into it, or funny drawings that we can cut out of magazines, and it will throw them on the screen just as well as an ordinary magic lantern with glass slides.

Picture 1 shows the lantern being used; the picture of an elephant in the lantern is being thrown upon the screen in front.



2. This is the lantern complete. A is the body of the lantern; B is the sliding lens; C is the chimney; D is the gas bracket; E marks the feet on which the lantern stands.

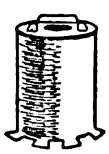
We can see the advantage of this at once. Probably we have hundreds of picture postcards or photographs that would look splendid if they were thrown on the screen. Well, we can use all these, and never get tired of this sort of magic lantern, because we shall always be getting new pictures for it of one kind or another.

Get a large square biscuit-box. Possibly we can find one in the house; if not, any grocer will sell one. This box will form the body of the magic lantern, as seen in picture 2.

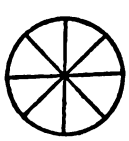
Now we must fix into it a lamp or a gasjet that will give a bright light. Of course, the brighter the light, the brighter the pictures will be on the

screen. An incandescent gas-mantle gives the best possible light, and one of these can really be fixed more easily than a lamp. We can buy an incandescent gas-burner complete, and any gas-fitter will supply a short bracket of the kind shown in the illustration. We have then only to make a small hole in the bottom of the biscuit-box, put the burner inside and the bracket underneath, and then screw them together. When this has been done, the burner will be fixed in the required position quite firmly.

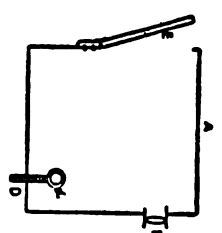
It will be necessary now to make four feet for the lantern to stand upon, as the gas-bracket at the bottom makes it uneven. Little cubes of wood, about two inches high, will form the feet. If we can find any wooden "bricks" in an old toy-box, these will do splendidly. We have only to place one at each corner of the box, to drive nails through the tin from the inside, and the feet will be firmly fixed in a few minutes.



5. Chimney made from coffee-tin



3. Opening for the lens



4. Diagram of the lantern looking from above

Now we must get a lens for our lantern. These are sold at the shops where magic lanterns and cameras are kept. We had better explain exactly what we want the lens for, and the man will understand. The lens should be mounted in a brass tube that slides backwards and forwards in another tube, so that we can focus the picture on the screen.

Now we must cut a hole in our biscuit-box, and fit the lens in the position shown in the illustration. This is quite easy, if we get from a tool-shop a small tin-cutter. With one of these we can cut the tin in a few minutes, and it will also be useful later on. The tin-cutters are merely strong scissors.

When the hole is cut, fit the lens into it. If the lens has a "flange," that is to say, a flat rim, with holes for screws, this will be very easy. All we have to do is to bore holes through the tin, and then fix the lens with strong brass "paper fasteners." If it has no flange, the simplest way is to cut eight slits, all meeting in a point, as shown in figure 3. Then bend the pointed pieces of tin inwards, and they will form a support for the lens tube.

We now have the gas-bracket and the lens in position. The next thing to do is to make a door at the back of the lantern, so that we can put the pictures in. Cut an oblong hole, about the size of a postcard, not in the middle of the box, but on one side opposite the lens, as shown by diagram in picture 4. When we have done this make a wooden door with hinges, as shown in the picture.

The lantern is now complete except for the chimney. This can be made out of an old coffee-tin. Cut a hole in the lid of the box exactly over the gas-bracket. Then make five or six cuts round the top of the coffee-tin, each about one inch long, bend back the pieces of tin, and then you will be able to fix the chimney to the top of your lantern with brass paper fasteners. One glance at picture 5 will make all this clear. At the bottom of the coffee-tin, which is now the top, we must cut a hole about as big as a twenty-five cent piece, and fix over it a flat piece of tin with paper fasteners. This opening will allow the hot air to

escape, but not the light. A few small holes must also be made in the back of the lantern, so that air may come in, otherwise the gas will not burn properly.

Now the whole lantern is complete, and if we have done everything neatly it will look quite nice. If we wish it to look particularly smart, we can give it a coat of Brunswick black. When we want to try our lantern, we fix a white sheet over one wall of the room. Then place the lantern on a table about eight or nine feet away, and connect the gas-burner by means of a rubber tube with the ordinary bracket on the wall. Put on the incandescent mantle, light the gas, and then put the lid on the lantern.

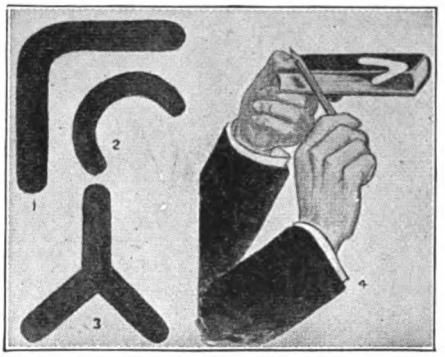
Now open the door at the back, and fix a picture postcard to the wood with drawing-pins, and the moment the door is closed a large picture of the postcard will be thrown on the white screen. We must slide the lens backwards or forwards until the picture on the screen is quite sharp, and then we can show just as many more postcards or other pictures as we please. By the way, whatever sort of pictures are placed on the door, remember to pin them on upside down. They will appear right way up on the screen.

HOW TO MAKE AND USE A BOOMERANG

ANY boy or girl can make a boomerang of cardboard that when flung out into space will travel for a certain distance and then return again.

Boomerangs can be made of various shapes, but the simplest and most familiar is that shown in the first picture. We take an ordinary postcard of medium thickness, and first draw the boomerang carefully to the proportions shown in the picture, making it as large as the postcard will allow.

Then, having drawn it, we lay the card on a flat piece of wood resting on an even surface, and, with a sharp penknife, cut it out clearly and neatly. No jagged edges must be left or the boomerang will not work. We must not cut it out with scissors, for that causes the card to curl, and a cardboard boomerang must be perfectly flat.



Three kinds of boomerangs, and the way to throw them

Another very good shape for a boomerang is that shown in the second picture, and here again we first draw the outline on a postcard, and when we have got the curve and the proportions quite accurate, we cut the weapon out with a sharp penknife, proceeding in exactly the same way as before.

A more complicated form of boomerang is that shown in the third picture. Here we have three arms, and this must be made in the same manner as before. We must be particularly watchful that there are no jagged surfaces in the angles where the arms join one another.

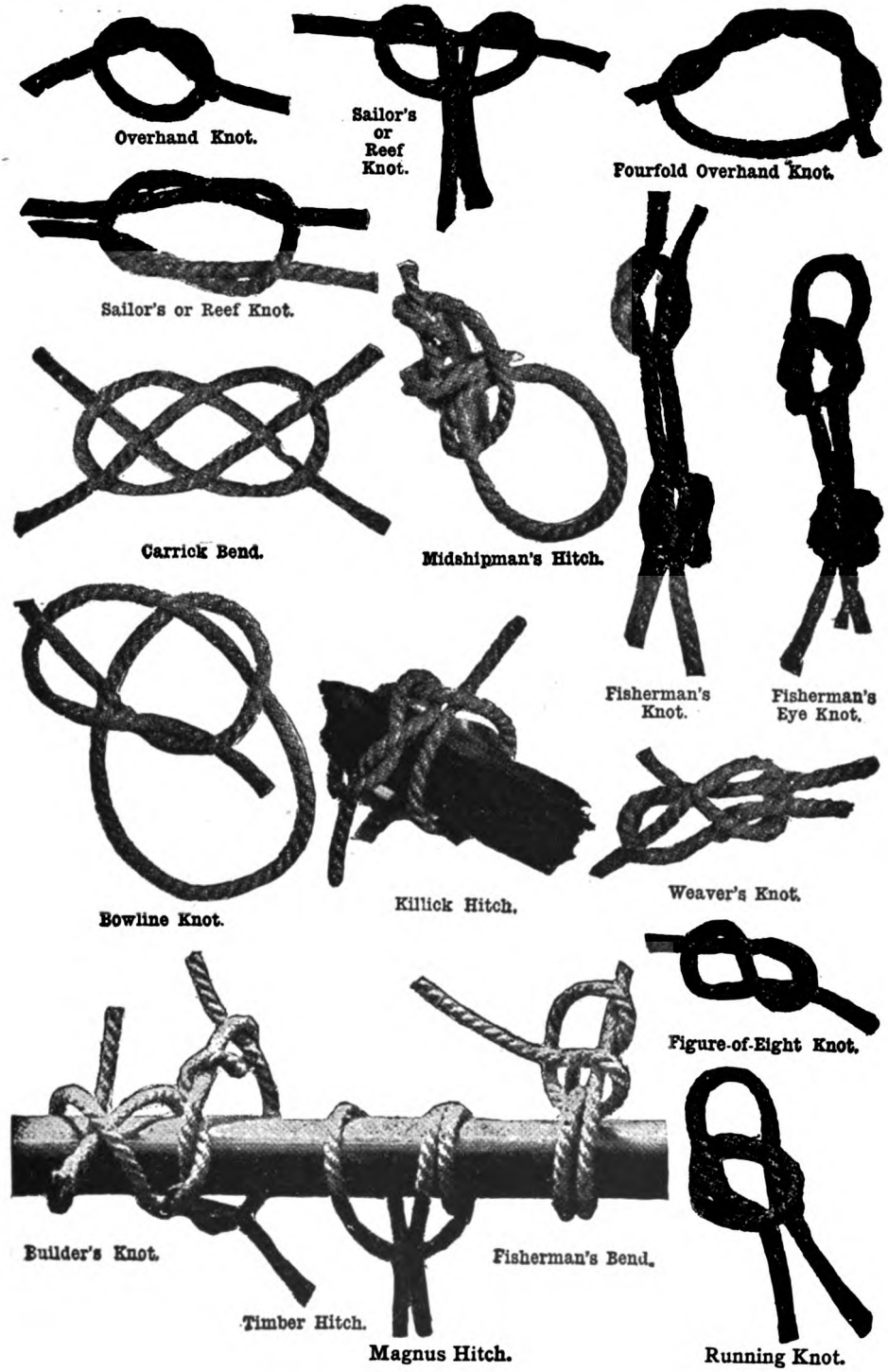
It will be noticed that in the case of all three shapes the ends are carefully rounded. This is important or the boomerang will not work properly. It may sail through the air swiftly and well, but it will not come back.

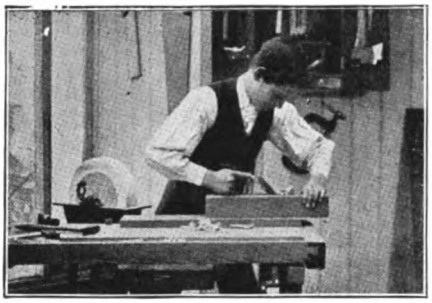
The method of throwing the boomerang is the same in all cases, and the picture on this page showing how the first shape is driven into space will explain how to act in each case. The boomerang is placed on some flat surface, such as a book, and then it is flicked off sharply with a pencil. As it sails off into space it will whirl round and round, and, after going some distance, will describe a curve and come swiftly sailing back home again.

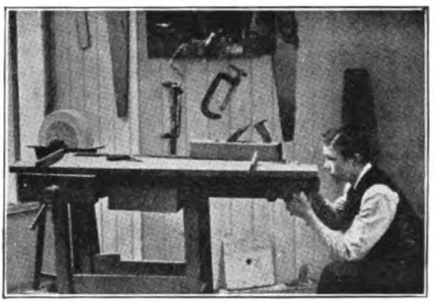
Any failure of the boomerang to return to its thrower will be due to faulty shaping or cutting out, or to too heavy cardboard.

The reason for the curious flight of the boomerang is not, even now, properly understood by men of science, but it is known that, owing to its shape, the air resists one part more than another, which causes it to fly in a more or less circular path.

KNOTS IN GENERAL USE BY SAILORS AND BUILDERS







THE BOY'S CARPENTER SHOP

EVERY boy should have a box of tools and know how to use them. With practice many things useful and ornamental may be made. The most commonly used tools are not difficult to manipulate; and although written instructions may help, a little practice should soon overcome any difficulties, especially if the right methods of holding, setting, and using are followed. When the tools are mastered it is possible to begin real work. The tools most needed will be a claw hammer, saw, chisel, plane, screw-driver, foot-rule, set-square, gimlet and possibly a hatchet. These should be purchased of the best quality one can afford.

Wood has what is called a grain, which is always up the way the tree has grown, and it can be split the way of the grain, but not across. When you wish to cut wood across the grain you must use a saw. When the grain of the wood is very regular you can split it evenly, but if the grain is twisted you cannot do so. Therefore, even when you want to have the plank of wood cut the way of the grain it may be necessary to use the saw instead of the hatchet. There are many saws. The kind you want is a handsaw, say about fourteen or sixteen inches long. You can use this both for sawing the long way of the grain and across. You must work the saw backwards and forwards regularly, not rocking it from side to side, or you will cut unevenly; and not jerking it out and in, or you will blunt the saw, and tire yourself. Before beginning to saw, make a pencil line on the wood where you want to cut it, and make the saw follow the line very carefully.

Using the saw

A hammer is a tool you cannot possibly do without. Its chief use is for driving and pulling nails.

A chisel is used to cut the wood where a hatchet or a saw would not be suitable. We use a chisel, for instance, to cut away the wood to make room for a lock

Using the hatchet

on a door, and sometimes before putting on hinges.

A gimlet is used to make holes chiefly when screws are to be put in. For ordinary driving nails it is not necessary to make holes with the gimlet unless the wood is very hard and liable to slit.

The screwdriver is for putting in screws.

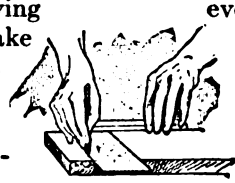
It is pressed against the head of the screw-nail with its point in the slot of the head, and is turned round at the same time.

If you look at an ordinary wooden fence and then at a door in a house you will notice a great difference in the surface of the wood. The fence will probably be rough, or almost hairy. The reason is that the door has been planed and the fence has not. All wood to which we want to give a smooth surface must be planed. Another reason for planing is that if we paint wood that has not been planed we use much more paint than we should use if the wood had been planed. In using the plane, push it forward on the wood steadily, and press upon it evenly all the time. The plane iron and the chisel must be kept sharp, and if you can afford to buy an oilstone you should do so. The stone is called an oil stone because it is used with a little oil in rubbing the edge of a tool upon it.

The first thing you might make with your tools is a box in which to keep them. You can no doubt find somewhere an empty soap or sugar box, or you may probably buy one from the grocer for a few cents.

Having the box, take the sides apart by pulling out the nails. Now measure off two pieces eighteen inches long and six inches wide. These are for the two sides of the tool box. Then measure off two other pieces six inches by seven inches to make the ends. Cut out these pieces, plane them until they are smooth enough, and nail them together so

The square


Using the square

The hammer

The chisel

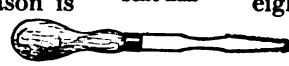
Using the hammer

Taking out nails

Using a chisel

Straightening a bent nail

The gimlet


The Screwdriver

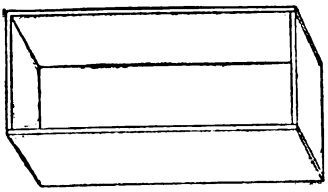
The plane

Using a gimlet

Using a screwdriver

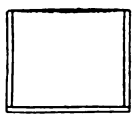
Using the plane

that they look like the top picture, with the end pieces fitted inside the sides.

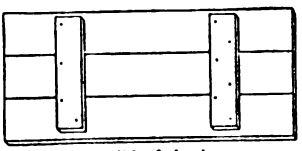


The ends and sides of the box

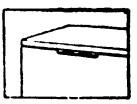
The total length when nailed up is eighteen inches, and the width will now be more than seven inches—it will be eight inches if the wood of the sides is half an inch thick. Now nail on pieces of wood to make the bottom, having cut them out as you did the sides.



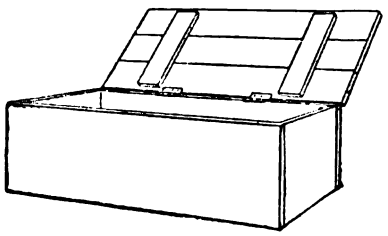
Box end, and position of bottom



The lid of the box



The position of a hinge



The completed tool-box

To make the lid, take one or more pieces of wood making the same width altogether as the bottom. Nail across them, as in the drawing, two pieces that do not go quite to the edge. The lid is now made. You can use it as a lift-off lid or you can put it on with hinges, which you can buy. Fix these on with screws, screwing them to the edge of the lid first. Then chisel away a little of the wood from the back of the box so as to make room for the hinges. You can put a lock on it if you like, and fit inside a tray to hold nails and other small things.

MAKING A SET OF BOOKSHELVES

IN PROCEEDING with our carpentry work, we must not go too rapidly. We shall do better work if we make very simple things at first. Another point to keep in mind is the utility of the articles we set ourselves to make. Here we shall see how to make an exceedingly useful article—a set of hanging bookshelves—which may be attached to the wall.

Everyone can use an article of this kind, and everyone with ordinary intelligence and the necessary tools can make one. The sizes given in the sketches are good useful ones, but the best sizes for the article to be made depend upon the space available for its accommodation. Thus everyone who makes the bookshelves from these sketches must first decide if these sizes are the best in his individual case, and if they are not he must modify the sizes given to suit his own case.

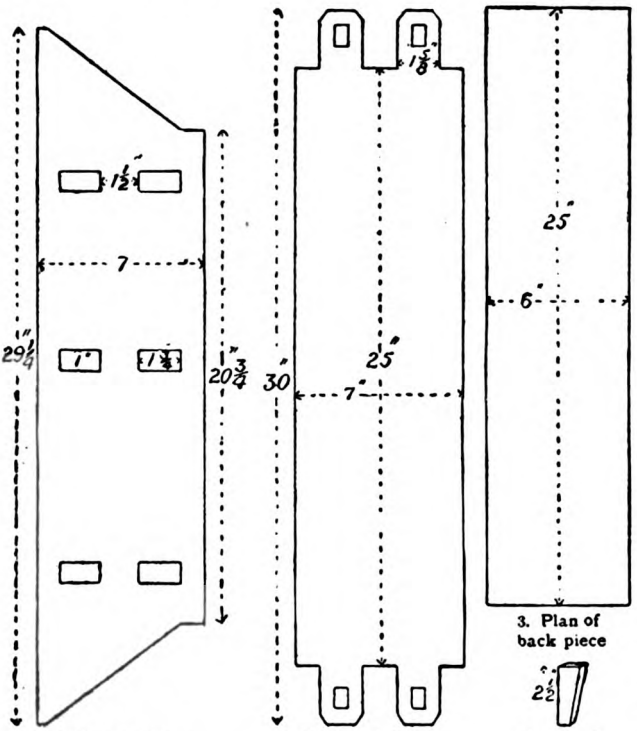
KIND OF WOOD TO USE

We have first to decide what kind of wood we shall use. We could use oak, beech or birch—perhaps oak looks better than the other two for the purpose—but all these are hard woods, and it will be much easier for us to use a soft wood, such as pine. Hard woods are much more difficult to work. We can use soft wood, and after the shelves are made we can stain them to imitate any of the harder and more expensive woods.

SIZE OF SHELVES

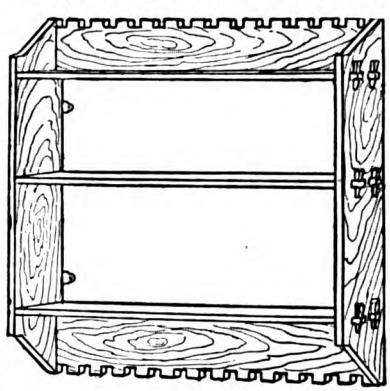
In picture 1 we show one side of our hanging bookshelves with all the sizes marked. We first cut out two pieces

of the wood we are using—pine, for instance—to this shape. They must be fairly strong, and we should make them so that the finished thickness shall be not less than one inch, so we had better use wood 1⅛ inch thick and reduce it to one inch by planing it. The holes in the sides we can make with our chisel, and we must be particularly careful that each pair of holes is exactly in the same horizontal line, so that the shelves may be quite flat. We must also see that the two sides are exactly alike. Having cut the two pieces, we must finish them carefully with the plane so as to have them true and smooth, afterwards rubbing them well with sand-paper. Use No. 1 sand-paper first, rubbing the surface and edges carefully until they are as smooth as the sand-paper can make them, and then we use No. 0 sand-paper, which will give them the final touches. It is more important to have the sides smooth than it is to have the shelves smooth, because the former are more exposed to view.



1. Plan of sides 2 Plan of shelves 3. Plan of back piece 4. Dowel

We shall now make the three shelves alike, and thereby simplify matters. Picture 2 shows the shape and the sizes to which we should make them. The thickness of these pieces when finished should not be less than ¾ inch and preferably ⅞ inch, so that the wood, when we begin, should be at least 1 inch. Having made the shelves, we fit them into the sides so that the ends go through the holes we made. We shall then want twelve taper pins, or dowels, for the holes in the ends of the shelves to hold them in position. Now nail on two back pieces, as shown in picture three, and the shelves are complete, except the mirror plates, as shown in picture five.



5. The completed bookshelves

JOINTS AND MORTISES

The simplest forms of joints are not too difficult for the amateur to make, which is fortunate, since one cannot go far in wood work without using them.

THE DOVETAIL NAILING, or sloping the nails (Fig. 13A). This method is necessary only when the nails are driven into the end grain of the wood, as in fixing the sides of the box to the ends, in which case the fiber of the wood does not grip the nail. Figure 13B explains the hold which a nail has when it enters the wood at right angles to the grain.

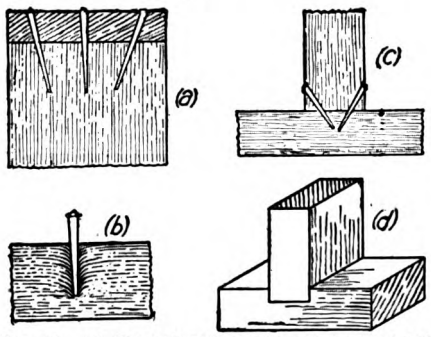


Fig. 13.—(a) Dovetail nailing; (b) nail forcing wood fibers apart; (c) skew nailing; (d) housing.

HOUSING (Fig. 13) is the name given to the joint when a groove of sufficient size is made in one piece of wood to admit the end of the other piece. Bookshelves are fixed in this way. Such joints may also be nailed through the ends but this should not be necessary if the shelf fits closely into the groove and there is a back to hold the piece of furniture rigid.

MORTISE AND TENON JOINTS are used in the making of doors, tables, and various kinds of woodwork. They are applied to the finest as well as to the heaviest kinds of construction, and vary in shape according to the work they have to do. The mortise is the hole, and the tenon is the piece driven into it, the word tenon meaning "that which holds." In house doors these tenons go right through the uprights, or "stiles," of the door, and are wedged on the outside edge (Fig. 15, *a*). This

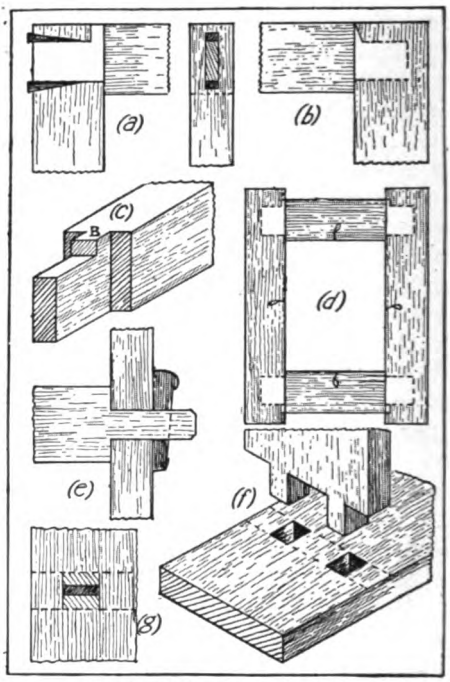


Fig. 15.—Mortise and Tenon Joints

"through" tenon is only necessary in large work, where extra strength is required. In this tenon the wedge should not be driven right in, the final position shown in Fig. 15, *a*, being about correct. When cutting mortises in stiles near the ends, always leave a waste piece on for strength in working, as in the case of the frame (Fig. 15, *d*). In Fig. 15, *b* is seen a "stopped" tenon, the joint generally adopted by cabinet-makers where any great strain or strength is not required, while the tenon itself is shown in Fig. 15, *c*, with a piece left on at B, which is called the "haunch." This haunch serves two purposes. It fills in the space made by the groove when the door is paneled as in an ordinary house door; and it gives rigidity and

strength to a rail, as in the frame of a table. The tenon and haunch is shown in Fig. 15, *b*, as it would be in a table, the haunch in this case being sloped. A tenon should occupy, laterally, about one-third the thickness of the wood. In cutting down the tenon be careful to keep the saw *outside* the lines.

Fig. 15, *d*, is an illustration of a door frame suitable for a cabinet or cupboard. It is made with a stopped tenon, and shows the haunch, which would only be used if the panel is be to grooved in. The "face" marks all finish off on the outside edges—a rule that should always be followed—and it will be noted that the uprights or stiles are longer than the actual length of the door for the reason given above, and are left on until the door has been glued up and dried, and is ready to be fitted into its frame. A tenon will enter the mortise easier if the end corners are cut off, as a sharp square edge is likely to catch on the uneven sides of the mortise.

Fig. 15, *e*, shows a form of tenon which goes right through the wood and protrudes sufficiently to allow a wedge to be driven into a hole in the projecting part. This is generally used in heavy work and church furniture, but is also a great advantage in such a thing as a standing bookshelf, as it allows for easy separation of parts if occasion requires. It is not glued, for it is evident that the further in the wedge is driven the tighter does the joint become. At the same time there is the danger of forcing out the extension piece if the wedge is driven in too far.

The through tenon shown in Fig. 15, *f*, is used when divisions in bookcases, cabinets, and showcases, etc., are fixed into the tops and bottoms.

Both sides of the boards should be marked for the mortises, and the cutting out will be made easier if a hole is bored right through first; then cut halfway through with a chisel, and turn the board over to finish from the other side. On no account should the mortise be cut through from one side only, as there is a danger of breaking the wood away at the back. Neither should the tenons fit too tightly across the width for fear of splitting the board.

MITRE JOINTS

The true mitre joint is made at an angle of 45°, as in picture-frames. In the first place, the mitre is sawed in a mitre box and the "return" or corresponding mitre should follow the preceding one, as 1, 1, and 2, 2, in Fig. 19, *a*, to ensure a correct intersection.

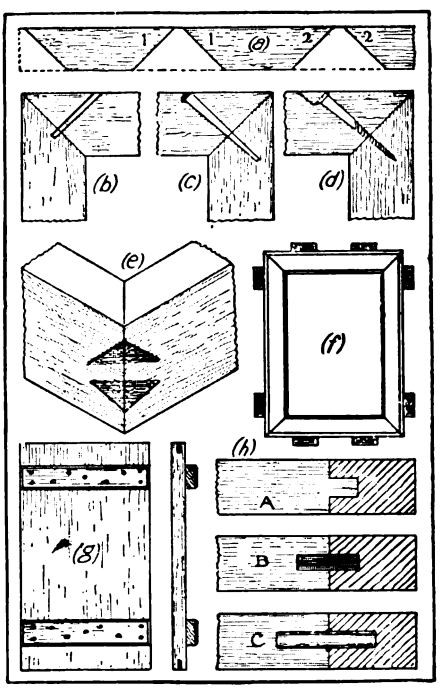


Fig. 19.—(a-f) Mitre joints; (g-h) clamping

It is a fatal mistake to cut the molding into lengths first.

If the angle is not a true one, the frame will not be square. It is quite

possible to cut a true mitre at once with a fine saw. Frame-makers use a hand-machine for the joint, but an amateur is not likely to include this in his outfit. The makers also use a vice to hold the joints while they are being nailed, but the worker at home must rely on simpler methods.

Another way of keying mitres in thin work, such as a tray, is to build up the sides and ends of the tray on a square piece of wood with dimensions equal to the inside measurements of the tray-to-be. The pieces are held in position by pins or a little glue. If a piece of paper is put between the back pieces and the wood, and the three are glued together, they can be separated subsequently by inserting the blade of a thin knife between wood and wood. The slightest touch of glue is sufficient for the purpose.

STAINING AND POLISHING WOOD

WOODWORK is stained to improve its natural color. The difference between stain and paint is that stain sinks into the fibers of the wood, and dyes them, but leaves the grain of the wood showing as plainly as before. Paint forms an opaque coat on the surface which quite conceals the material beneath. Generally stain is used to make a cheap wood look like an expensive one. The colors used are chiefly imitations of walnut, mahogany, and rosewood. These stains are used on lighter colored common woods, such as pine, and only for good appearance and not to deceive people, for anyone with a little experience can tell what the wood really is.

DIFFERENT COLORS IN STAINS

Sometimes, though not often, colors quite different from that of any wood, such as green, blue, or red, are used as stains. Very often fancy woods are darkened and improved in appearance by stains of the same color as themselves. Stain is used also to darken lighter parts of the wood to the same shade as the rest. Wood may be darkened in colors slightly by rubbing oil into it. Oak and mahogany can be darkened by ammonia. The usual way to do this is not to wet the wood with it, but to shut it up in a case or small room with saucers of liquid ammonia. The fumes of the ammonia darken the wood in a few hours. In all cases stained wood must be darker than the natural color, for a dark surface will show through a lighter stain.

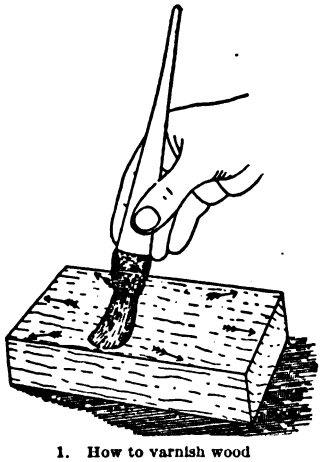
Stains for wood are sold ready for use in small bottles. They may be put on with a brush, or rubbed in with a rag. The neater way is to use a brush. Generally two coats are given. The best result can be obtained by using weak stain and applying a number of coats, allowing each to dry before putting on the next. The surface must be smoothed with sand-paper before the first coat and after each coat has thoroughly dried. Otherwise it will feel and look rough, for anything which wets the wood causes its surface to roughen as it dries. Varnish stains are often used instead of simple stain. These are varnish and stain combined and are not so good.

EFFECT OF VARNISH

Varnish does not conceal the character of the wood beneath it, for it is almost transparent unless something is added to color it. It simply produces, when dry, a hard, glossy film on the surface, which protects the wood from dampness and dirt. Quick-drying varnish consists of shellac dissolved in methylated spirit. The

spirit evaporates and leaves a thin layer of shellac on the wood. Shellac varnish is used only for indoor work. In making varnish for work exposed to the weather it is necessary to use linseed oil instead of spirit, and copal, or mastic in place of shellac. Varnish may be used either on the bare wood or on paint.

Varnish is applied with a brush. Two or three coats are put on, each being allowed to dry and then smoothed with fine sand-paper before applying the next. For large surfaces a large brush should be used, so that



1. How to varnish wood

the varnish can be spread quickly. For small work a small brush is better. The varnish should be put on uniformly, so that some parts shall not be more thickly coated than others. Varnish should not be allowed to run over edges or corners of the article being varnished, and the brush should be used so that it does not leave marks of its own all over the work. The best way is to take one surface at a time and cover it with varnish as quickly as possible—that is, if ordinary shellac varnish, which dries quickly, is being used. The brush should be held as shown in picture 1, and should move in line with the grain of the wood. If it is used across the grain, marks of the brush will show more distinctly. To prevent varnish from getting squeezed out of the brush and running over the edges of the wood, the brush should always move outwards to the edges, as indicated by the arrows in picture 1. In approaching the ends of the wood it goes directly to the edges, but in passing along the sides its direction is only very slightly diagonal towards the edges there, so that the movement shall be as nearly as possible in line with the grain. Spirit varnish dries quickly, but to obtain the best results each coat should be allowed several hours to harden before sand-papering it down for the next. After the first coat, old sand-paper worn smooth should be used, and the work is not rubbed down at all after the final coat. Sand-paper should always be rubbed in line with the grain of the wood. If rubbed across, it scratches the surface too much.

POLISHING AND VARNISHING

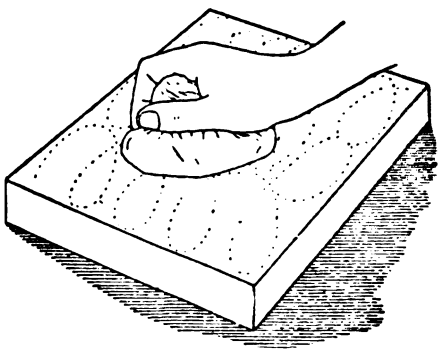
The difference between polishing and varnishing is chiefly in the method of application, for shellac varnish and polish are practically the same thing.

The distinction between varnishing and polishing is that varnishing is done with a brush, and polishing with a rag. Polishing requires more skill and time, but it gives a smoother and glossier surface than varnishing. It is important in polishing that the pores of the wood shall first be thoroughly filled, so that the polish cannot sink in and lose its luster. A number of applications of polish with long intervals for drying will do this, but it is quicker and cheaper to fill the pores with some other substance before beginning to polish. The filler is generally whiting or plaster of Paris dissolved in water, turpentine, or oil, and colored to match the wood. It is

rubbed in and allowed to dry, and then the surface is sand-papered smoothly. The wood is now ready to receive the first application of polish.

The rag used in polishing is called a rubber. It should be a piece of soft white linen. This is used as an outer covering to a pad of cotton-wool.

The cotton wool is moistened with polish, and the single thickness of rag encloses it and is drawn up like a pudding-cloth at the top and grasped by the hand while it is used. The pressure on the rubber should not be heavy, and a few drops of linseed oil are put on the rag to make it move about freely without tendency to stick. The polish is put on the cotton-wool only, and gets squeezed through the rag in rubbing. The method of rubbing depends to some extent on the shape and size of the work. First, it is necessary to cover the surface of the wood with polish as quickly as possible. This is done by moving the rubber in large sweeps either with or across the grain or both. The direction is not important as long as the polish is rubbed uniformly all over the surface. On a large flat surface, as in picture 2, the rubber may be moved in curves or spirals, as shown by the dotted lines. These are only drawn as lines, but the broad surface of the rubber would, in following them, polish the entire area of the wood. For getting into the corners of panels and similar parts the rubber must be squeezed into a pointed form which will reach those parts. After the polish has been applied in this manner, the work must be laid aside for at least a day. Then a second application is given in the same way as the first.



2. Polishing a large surface

In the best work this process is repeated a third time or even a fourth, and long periods are allowed between each to allow the polish to sink in as much as it will. In sinking in, and hardening, it loses some of its gloss, and as long as this occurs the work can be improved by fresh applications of polish. This is called bodying in. The final process in polishing is called spiriting off. In spiriting off, the rubber is moistened with methylated spirit instead of polish, and is rubbed lightly over the surface to remove smears caused by the rubber in bodying in, and also to take up the oil, which, when present, gives the surface a dull, greasy appearance. The last movements of the rubber should follow the grain of the wood—that is, the rubber should move in straight lines with the grain.

THINGS A BOY CAN MAKE FOR A BAZAR

Here are other things that boys can make for a bazar:

Toasting-forks made of wire. The wire can be bought at any ironmonger's, and should not be too thick; it can be twisted double or treble to give sufficient stiffness to the handle.

A set of furniture for a doll's house—chairs and tables—made from firewood, the pieces being joined together with glue.

A boot-brush box with a hinged lid can be made from an old egg-box.

A flower-pot case made of wood and covered outside with cork bark, or enameled in some dainty color.

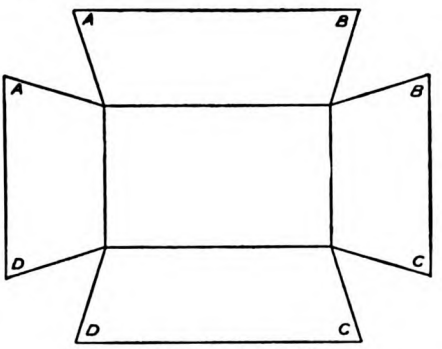
Picture-frames of different sizes and shapes.

Clock-cases, handkerchief-boxes, letter-racks, wall-brackets, and other articles made from cigar-boxes by fretwork.

THINGS FOR GIRLS TO DO

HOW TO MAKE A GIRL'S WORKBOX

HAVE you ever thought of the joy it brings to have a real workbox of your own? Let us try to learn to make a box like the one in the picture.

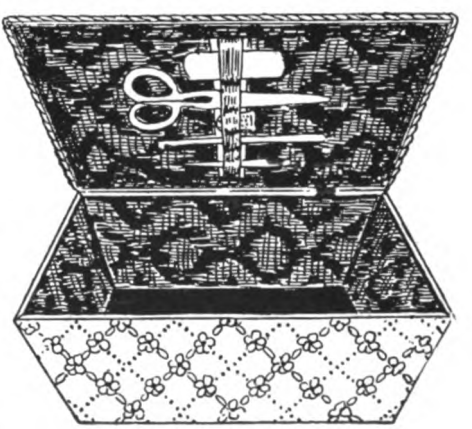


The pattern of the girl's workbox

Take a piece of cardboard thick enough to make a firm foundation, and on this draw a pattern similar to the above, enlarged to the size desired for your box. Cut the cardboard all round the outlines of the diagram. Bend the four pieces which are intended to form the four sides. Do this while following the lines carefully, so that the bottom of the box will be quite even. Straighten the cardboard again, and cut two pieces of cretonne, each one covering entirely the piece of cardboard which includes the bottom and sides of the workbox. Cut the material about a quarter of an inch larger all round than the cardboard, to allow for turning in the edges, which otherwise would fray and look untidy; then glue (or overcast) the cretonne on the cardboard, back and front. When this is done, let it dry for one day.

Then bend your covered cardboard as you did before. Join the corners A together by sewing the cretonne on the two sides with over-and-over stitches, using a needle with strong thread to secure the corners, top and bottom, very firmly. The same thing must be repeated in the corners marked B, C, D.

The workbox now stands, is covered and lined. Some cord sewn round the foot of the box will make a neat finish and slightly raise the box. Now the cover must be made. Cut a piece of cardboard to fit exactly the top of your workbox; then, before putting on the cretonne as you have done on the other part, put a layer of cotton to form padding, and cover it over with the material. Do this on both sides of the cardboard, taking great care to turn the edges in, as described for the other part of the box, before gluing the cretonne down. A strip of material is fixed on the inside of the lid, and sewn at regular intervals, to receive a thimble, a pair of scissors, crochet needle, and other things. The cover is then put on the box part by slipping two small pieces of cretonne under both cover and back of box, one on each side, to form hinges. These are then sewn very firmly, so that the lid can be opened and closed.



The workbox lined and ready for use

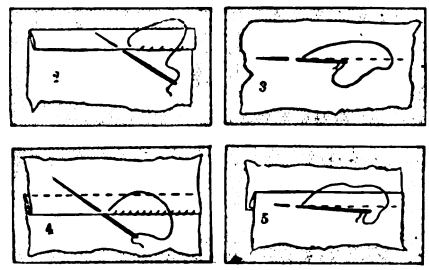
HOW TO USE THE NEEDLE

NOW that we can make a work-box of our own—we must find out how to use it. We are going to dress a doll. We shall cut out the clothes and make them as our own clothes are made. First we shall make the little underclothes, one by one, and then the frock. But before we can do anything at all we must know how the different stitches holding the pieces together are made.

We all think that it is the easiest thing in the world to thread a needle, but the right way to do it is to thread it by the end just cut off the spool, making a tiny knot at the other end. If the cotton is put through the needle at the opposite end all the gloss goes out, knots, and breaks off very easily. Always choose a needle that is just a little thicker than the thread. This will open the material enough for the thread to come through without any unnecessary tugging.

The left hand holds the piece of material between the thumb and first finger, letting it fall loosely over the back of the hand, the little finger just holding it in place. The right hand holds the needle and pushes it in and out of the material, a thimble on the third finger helping to push the needle through. The width of the first fold of a hem should be about one-third the width of the hem required, but in very narrow hems the first fold is the same width as the second. If, however, you intend to sew very fine material, such as muslin, the fold must be the same size as the hem, otherwise the rough edge will show through.

When you have decided what the size of the hem should be, turn the double fold and press it down firmly with your nail, then tack it, with long, even stitches. This will save time, for the hem will keep pressed down in position, and it will help to get the work straight and even. The needle is then put in the material, as you can plainly see in the picture (2), the stitches being done from right to left in a slanting position.



These sketches show you how to make the different kinds of stitches. 2 is a hemming stitch, 3 running, 4 running and felling, and 5 a French seam.

There are many different kinds of stitches, but for our present purpose it is only necessary to know a few of them. The running stitch (3), is one of the most useful to learn, for it is with this stitch that seams are made and materials gathered.

If you are anxious to learn how to do really beautiful sewing, try first on fine canvas, or on any other very coarse material, where the threads can be easily sewn, taking two threads on the needle and going over two. You will be surprised to find how easily the hand and eyes will be trained to work evenly and regularly, until you can work quite pretty little stitches on any material without counting the threads, which is always a slow and tedious method of working.

When you can do the hemming and running stitches quite evenly, you have mastered the most difficult part of sewing, for all the other stitches are more or less made from these two.

If you look at picture 4, for example, you will see a little pattern of running and felling, which always looks full of difficulties to little girls, although it is simply running and hemming.

Two pieces of material are put close together, the back piece slightly overlapping at the top to allow for the folding over of the raw edge, and joined together, on the wrong side, by running stitches. The material is then opened under the seam, laid flat, and the two edges folded over like an ordinary hem.

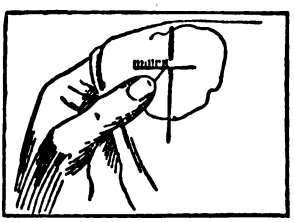
A glance at the picture will show the work far better than it can be explained.

The easiest way for little girls to do running and felling is by French seams. It will probably be the most popular way of doing the seams in dolly's underclothes. If you look at the picture (5) you will see that this kind of seam is simply a double row of running stitches. The first row is done in the ordinary way, then the raw edges are cut as short as possible, and the seam turned inside out, a second row of stitching giving perfect neatness in the finished work. Remember, however, when doing these seams that the first row of running, instead of being done on the wrong side, as for running and felling, is always done on the right side, the second row putting the first one out of sight.

Gathering is done with exactly the same stitches as running, only it must be done with strong thread so that it will not break. The thread is pulled to gather the fullness. No knots or joins must be allowed in the thread, or it will not come through the material to form gathers. Measure the piece of material you want to gather, and take a long enough piece of thread to leave two or three inches to take hold of when you want to draw it. It is always better to do two or three rows of gathers in case one should break, besides giving more evenness and regularity to the gathers.

If the gathers are done on fine material for underclothes when the thread has been drawn, a coarse needle should be used to stroke down the material between each gather.

Buttonhole stitches come next, and these are by no means too difficult



6. Buttonhole stitches

to be attempted. They are really quite easy when you know the way. Try first on a piece of canvas or coarse flannel, and make even and regular stitches quite close to each other. The picture (6) shows just how the stitches are made. Let the thread go under the point of the needle and pull the needle down gently, letting the thread cross over itself where the needle came out. If you follow these directions, and look at the picture, you will find the stitch so easy that you will really be surprised.

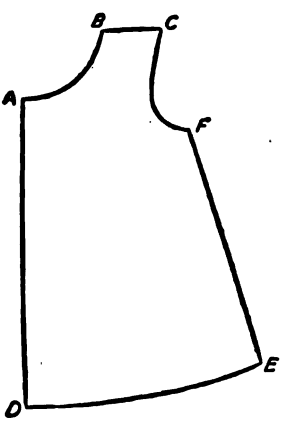
THE DOLL'S FIRST LITTLE GARMENT

WE HAVE learned how to do the different stitches that are needed, so now we should be able to undertake the fine stitching for the garments that we are going to make.

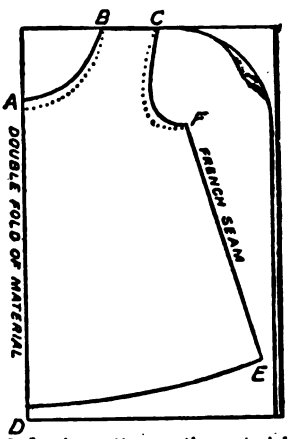
We will start with the little chemise. If you look at the picture (1) you will see that the pattern is quite simple, and very easy to cut out if you read this article carefully.

Draw the pattern to fit the size of your doll on a piece of paper, and mark it A, B, C, D, E, F, like the

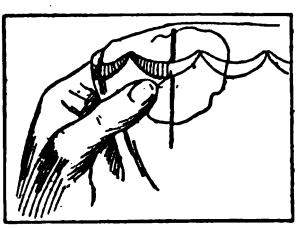
sketch. Nearly all patterns are cut out in halves—that means that nearly all garments have, of course, two sides, or two parts, which are exactly alike, and it is far easier to get these exact if we double the material, lay the pattern on it, and cut them both at once. This is why we always, or nearly always, speak of a pattern as being *half the back* or *half the front*, and so on. Take a piece of fine muslin, or, better still, nainsook, twice the length and twice the width that you want the little garment to be, allowing enough over for seams and hem. Now fold the material in half, and then fold it in half again. When you have done this the shape of the material should be *as it was before*, only smaller.

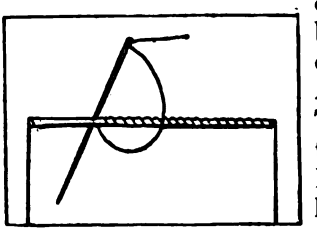


1. How to cut out the pattern



2. Laying pattern on the material.


3. Buttonhole scallops


4. The whipping stitch

Before going farther be sure that the two single folds of the material are at the top, and the double fold at the side. If this is not quite clear to you, look at picture 2 which shows the material folded. Lay this down on the table in the position shown in the picture, and lay the pattern on it. Pin the pattern to the material before it can slip out of place; then take a pair of scissors and cut all round the outlines of the pattern, except the parts between B and C (this is the shoulders), and between A and D (this is the middle of the chemise, as you will see when you open the material out after it has been cut).

When you are cutting remember to leave half an inch for the double seam under each arm, and an inch and a quarter for the hem at the bottom.

Take off the pattern and unfold the material. The two sides of the little garment are now shaped and held together by the uncut folds of the shoulder. If you look at your own little chemise you will find that the front of the neck is cut lower than the back. Now turn to the picture (2) again, and you will see that there is a dotted line below the one between A and B. The line between A and B represents half the back of the neck, and the dotted line half the front. So to get the front, take your scissors and cut out the material a little, being careful to slope out more at the center than at the sides. Then slope out each little sleeve (between C and F) in the same way.

Before starting the sewing we must be sure that our hands are spotlessly clean, for on its neatness and cleanli-

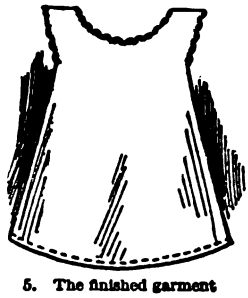
ness depends the success of our work. To look well, needlework must be kept quite fresh, or its charm will be gone, however neat the work may be.

Thread a short needle and begin with the seams on each side, joining them either by running and felling them, or by a French seam.

The next is the hem at the bottom. Turn up the material about 1¼ inches. You will remember that we allowed an inch and a quarter when we cut the material. The quarter of an inch is for the first little fold, and the inch will be the width of the hem. Measure an inch and a quarter all round, turn this down and tack it to keep it in place. A good way to measure the hem and to be certain that it is quite even is to get a piece of stiff paper—or a visiting card is better—measure an inch on it, snip it with the scissors to mark it, and use it as you would use a tape measure. When your hem is even fold the rough edge under a quarter of an inch, and tack it again, and then hem it round with neat little stitches.

If we have been practicing all the stitches which we learned, we shall be able to do some small buttonhole scallops round the neck and sleeves, in which case we shall have the daintiest little ornament that one could wish for. If you look at picture 3 you will see how the material is marked in scallops all round for the button-hole stitches to be worked on. The picture shows how the stitches should be narrow at the top of each scallop, and get wider in the middle. If you cannot get this quite even, draw a faint line, like you will see in the picture, and work over it.

But if this is too difficult we can make a little hem and sew on the end of it a piece of pretty Valenciennes lace. As the neck is round, and not straight, it will not be very easy to fold the hem in the usual way; but if you will try to roll the edges and make only a tiny hem, you will find it will not be nearly so difficult.



5. The finished garment

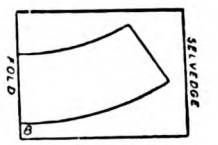
Now for the lace. This should be first gathered and pulled up, so that it makes a little frill. When the lace is pulled up full enough—do not let it be too full—sew it on to the edge of the hem with tiny whipping stitches. In sewing the lace to the chemise, do not put the two back to back and then sew, but draw them together as you would sew together the two edges of a hole in a glove. This is the only way to get the lace to set quite flat.

And now your little chemise should look just like the one shown in picture 5.

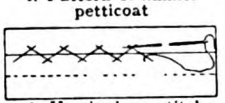
THE LITTLE PETTICOATS

THE next little garment we will make is the flannel petticoat. The pattern of this is very easy, as we can see from pictures on next page. Picture 1 shows half the pattern. Cut your pattern, and lay it on a piece of soft, fine flannel which has been folded in half, taking care that A B lies against the fold. Cut all round, *except between A and B.* To make the back seam, join the two edges as for running and felling, but instead of felling the edges, turn them over, and fasten them by herring-boning

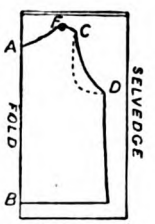
them "*raw-edged.*" Leave a placket-hole at the top and make the edges neat by two tiny hems, herringboned, like the seam, to keep them flat. When you have gathered the material, regulate the gathers, so that the front of the petticoat is nearly flat, and the fullness is at the back.



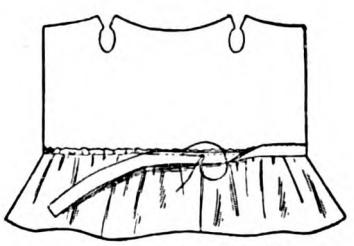
1. Pattern of flannel petticoat



2. Herringbone stitch



3 Pattern of bodice



4. Fastening bodice to skirt

5. The flannel petticoat

6. The white petticoat

The next thing to do is to make the little bodice which has to be joined on to the petticoat. Look at picture 3, and you will see half of the very simple outline of the pattern needed to make this bodice. It is in one piece, and needs no seam except the tiny ones on the shoulders—that is, between E and C.

After you have drawn the design the right size to fit your doll, fold the piece of flannel in half and put the edge of the pattern marked A B on the fold of the flannel. Then pin it, and cut along the lines of the pattern, except between A and B, leaving enough for the turnings.

The dotted line in picture 3 is to show where to slope out the material for the front of the armhole.

After the seams on the shoulders have been done, either with a French seam or running and felling, the little bodice must be finished off at the top with buttonhole stitch to match the bottom of the petticoat. To make the material strong at the back to hold the buttons and buttonholes, which have to be sewn next, a little hem, herring-boned, should be made on each side. If we have cut our pattern correctly, we shall find that we have quite enough material for this without adding any more. When the bodice is finished, the lower part of it is run on to the gathered skirt.

Join the bodice to skirt, by running stitches, as picture (4) shows. But it would be very untidy on the wrong side if we left the raw edges like this, so to make it neat and dainty, a strip of nainsook is run along the gathers, and then turned over and neatly hemmed down just above. But the stitches must be very tiny ones, because they will show on the right side.

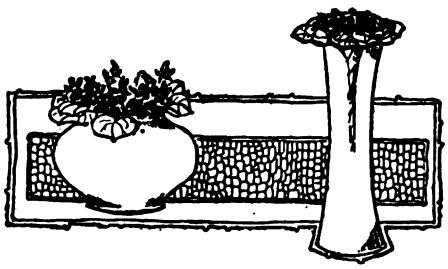
Trim the raw edge of the skirt part with buttonhole stitches, put on another button and buttonhole to fasten the waist-band, and your little flannel petticoat is finished, and will look like picture 5.

The white petticoat, which goes over the flannel one, is cut and made in very much the same way. The only difference lies in cutting out the skirt part of the trimming. The bottom should have two little tucks and a narrow hem, edged with tiny Valenciennes lace. These tucks and the hem will take up about one and a half inches of material, so when we cut out the skirt part of the white petticoat it must be longer than the flannel one. No pattern is needed. It is simply a *straight* piece cut about one and a half inches longer than the flannel one.

But the important thing to remember is to cut it "on the straight," not "on the bias," like the flannel one is cut. Material cut on the bias pulls very easily, and is difficult to tuck. Material that is cut on the straight—that is, in a straight line with the selvedge—is firmer and keeps its shape much better. The reason why we cut a flannel petticoat on the bias is, because it sets better and is less clumsy round the hips, for flannel is a clumsy material. The seams of the white petticoat should be run and felled, not herringboned.

ARRANGING FLOWERS FOR THE HOUSE

THE world has paid every woman a charming compliment. It has credited all of us with the ability to make our surroundings beautiful. Have you not read in many books that the heroine possessed a magic touch? When she had been there the room seemed to show an extra daintiness, the place wore an added charm, an air of comfort and coziness that it did not possess before. But, unfortunately, the novel gave no precise direction as to how she did it.



This shows the right and the wrong way to arrange violets and flowers like them. They should be loosely arranged in a low vase, and not cramped up in a high vase where they can hardly be seen.

These things are not arrived at by instinct. The good fairy who deals out the birth-gifts is not so lavish as we are led to suppose, and seldom gives to anyone so big a gift that there is nothing left to learn. She just gives a little bit—just enough to show it is there—and one has to learn the rest.

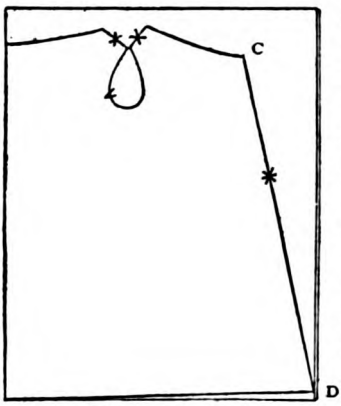
We shall not be able to learn here everything that our favorite heroines are supposed to know, but only a few things about one simple part of the subject—how to arrange flowers.

We wonder if you have ever thought that the size, shape and color of the vase is a most important point? For instance, daffodils, which are heavy flowers, should always stand in strong china—for preference, green glazed ware. There is something so strong and sturdy about their growth that they need a good support and plenty of water; so don't put them into frail china vases that will topple over with a breath of wind because they are top heavy.

Also remember how the daffodil grows. How many leaves go to one daffodil? Hundreds! Well, you cannot get hundreds into a vase, but you can get a good many, and you will find the flowers look far finer with a plentiful supply of leaves, because—and this point applies to every kind of blossom—they *grow like that.*

THE DOLL'S LITTLE FROCK

THE little frock illustrated is a simple one. It is made entirely in one piece with only two tiny seams on the shoulder and one in the center of the back. The two armholes are for the little puff sleeves which are also made in one piece with a little seam under the arm. The first thing to do after cutting is to make the seam at the back. This is marked C D in the picture. A little French seam such as we have already done for the underlinen will do very well for this frock, especially if you have been able to coax mother to give you a piece of Japanese silk, or some other thin material.



1. Pattern of the frock

2. Sleeve pattern

Do not make a seam at the back right up to the top of the neck, but leave a placket-hole rather more than half-way up, just about where the star is marked on picture (1). Three or four little buttons and buttonholes are needed to close the frock. The hem should be about two inches wide all around with a quarter of an inch turned inside. The neck part is simply gathered into a little straight band which is first run edge to edge with the main part of the frock and then hemmed over the gathers. If this little band is made broad enough it can be doubled over to form a little turn-down collar, which may be ornamented with feather stitching, while a lace frill may be added to make it daintier. A wide tape sewn inside at the waistline rather low down, will, if sewn top and bottom all round, act as a slot in which a fine silk tape may be put through to gather the little frock as picture 3 shows.

The pattern of the little sleeve is plainly shown in picture 2. The part between E and F in the picture is the top and when gathered, and the thread pulled up, will form the little puff.

3. Back of the frock

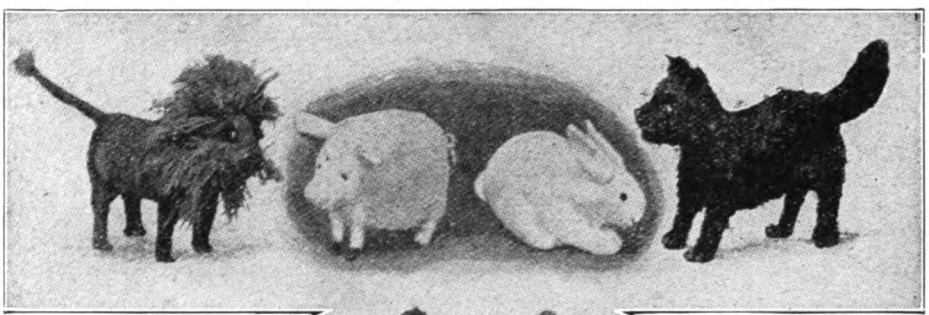
Join the line E G to F H by a French seam and you will begin to see the shape of the sleeve. The top part as we have said, is gathered drawn up, and made to fit the hole left for it in the frock. The side marked F H to put under the arm and the sleeve seam is joined to the notch seen in the pattern. Arrange the fullness to come at the top of the sleeve on the shoulder. The bottom of the sleeve—that is, the part between G H in the picture, is also gathered and then put into a straight band of material which is made large enough to turn over just like the little collar. This too is trimmed with a row of feather stitching.

The little frock shown in the picture has what is called a long waist—that is, the waist trimming is arranged to come much lower than the doll's real waist.

HOW TO MAKE OUR OWN ZOO

A LITTLE while ago most of the creatures in our Home Zoo were lying together all in a heap at the bottom of somebody's piece-bag. They did not look much like animals then, but that was before they were touched and brought into shape by the wonderful fairies Needle and Thread. Our kitten was just a bit of black plush left over from the trimming of a coat; our fierce lion was a corner of fawn-colored, smooth-faced cloth from a tailor-made suit; our fat pig and dear little white bunny were odds and ends of eider-down; and our curly dog was a scrap of imitation astrachan from somebody's winter jacket. But we just cut them out, and sewed them together, and fed them well on wadding, and here they are—all that you see in the picture, and many more. Making one's own Zoo is great fun. It is so nice to have the animals to play with. They will all stand up; and if their feet are glued to a small stand, with wheels—such as any boy can make—little children will be delighted to draw them about. If they are very nicely made they are quite pretty models, and will readily sell at a bazar.

But before we start to make them, there are a few things which we must always remember if we want really to succeed. If we number them it will help us to remember.



Animals to make at home

Some members of the zoo

How the cat looks when made

1. The best materials are tightly woven stuffs that are plain on one side and fluffy or shaggy on the other. Thin and loose cloths that easily fray are troublesome. Beaver cloth, all imitation furs—if they are not too thick—eider-down, canton flannel, plush, and velveteen, all make up splendidly.

2. In cutting out, first note which way the pile, or "nap," goes, and take care to place the pattern so that it will stroke from the head to the tail, as in nature.

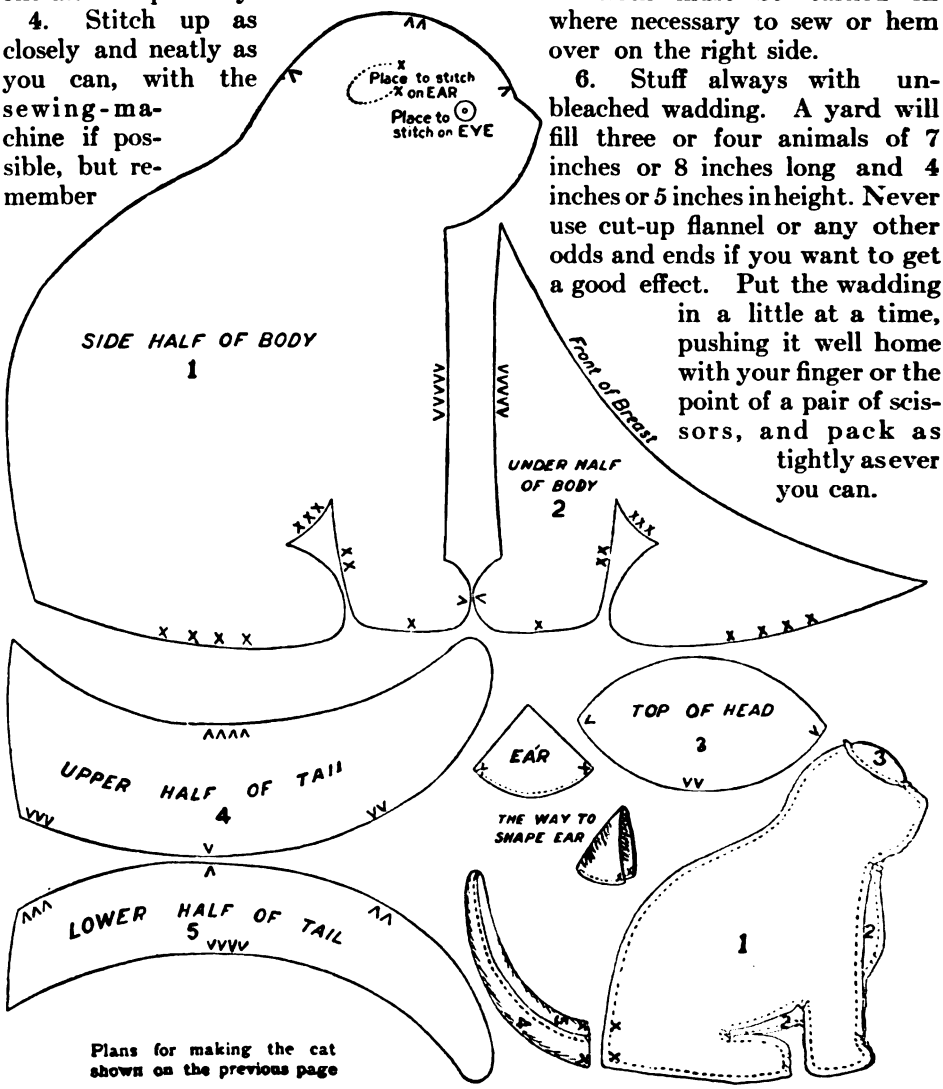
3. All the patterns are cut out in halves, so that you will have to double

the material. We shall understand this better later. But be very careful to see that the two halves face each other, and cut out with neatness and exactness, making the pieces all fit one another precisely.

4. Stitch up as closely and neatly as you can, with the sewing-machine if possible, but remember that very firm, close seams are most important.

5. All animals have their principal seams sewn on the wrong side; but if the cloth is thick and firm, with a good nap, some parts—such as the holes where the legs are fastened in, and sometimes the legs themselves—may be sewn raw-edged on the right side, and the nap at the margin pulled over the stitches to hide them. Thinner cloth must be turned in where necessary to sew or hem over on the right side.

6. Stuff always with unbleached wadding. A yard will fill three or four animals of 7 inches or 8 inches long and 4 inches or 5 inches in height. Never use cut-up flannel or any other odds and ends if you want to get a good effect. Put the wadding in a little at a time, pushing it well home with your finger or the point of a pair of scissors, and pack as tightly as ever you can.



Plans for making the cat shown on the previous page

Now we may start on our first animal—the cat. Gray velveteen or plush makes the prettiest cat, but black will do. The cat, when cut out, is in eleven pieces—namely, two upper halves, two under halves,

two pieces, upper and under, for each of the ears, the upper and under halves of the tail, and a lemon-shaped piece on the top of the head. We cut out the pieces to the shapes shown in the plans, which we can trace on thin paper. Let us begin with the side half of body which is marked 1. We cut out two pieces this shape, making them exactly alike. We cut out two pieces of the under half of body marked 2 in the picture, then one piece for the top of head, marked 3, one tail piece marked 4, and another tail piece marked 5, and, finally, two ears to the shape given in the picture. We must remember to make every piece the size given in the pictures.

Now we are ready to sew the pieces together. The pictures are marked with V's and X's, and these show what pieces are to be sewn together. The piece marked VV is to be sewn to the other piece marked VV, and so on. We begin by stitching the under halves on to the upper ones, being careful to stitch very closely round the toes. Next stitch up the tail, turn it, and stuff it. Stitch on the lemon-shaped piece to the top of the head in the position shown in the pattern. Sew up the upper animal, beginning at the throat and going over head and back, and ending at the tail. Be careful to keep the halves in proper position.

Now turn the cat and her four paws, and begin to stuff her—first the head, then the paws, then the body. When she seems nearly fat enough, begin to sew up at the tail, and work along, poking in more stuffing as you see it is needed, until you finish up under the chin. The two front legs will probably have to be caught together with strong thread to make pussy sit up properly, and her tail, hemmed at the base, should be curled round her toes, so as to give a natural position.

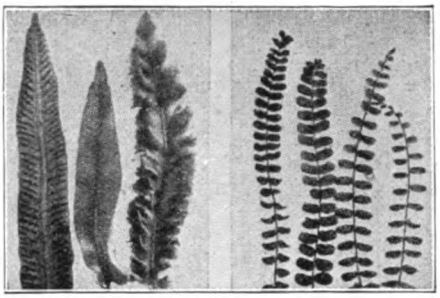
The ears must be made and turned, after being fastened neatly in the right position, and the two outer edges folded over to meet in the middle. Then you will have a pretty little ear to sew on in position. Beads or sequins make bright eyes; but, if the cat is to be a toy for a young baby, black worsted eyes, just stitched, are safer. A nose and mouth may be also marked in worsted, as here shown, and bunches of white thread can be sewn on for eyebrows and whiskers. If you finish up by marking the "tabby" pattern in ink, copying from a real cat, and brush the stiffness out when dry, you will find you have made a very charming cat.

COLLECTING FERNS FOR A ROCK GARDEN

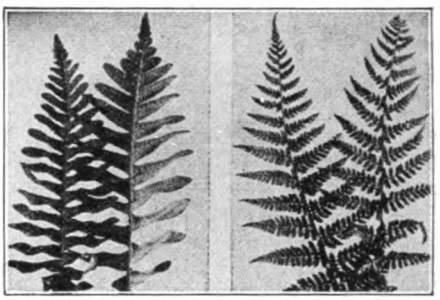
NO GARDEN is complete without its ferny nook, and any ugly old corner can be made beautiful in a short time by planting ferns, the graceful fronds of which will, when they unfold, hide every trace of ugliness.

Almost any time of the year we can go on a fern-hunting expedition, and very enjoyable such an excursion is, especially in the autumn, when the ferns appear in all their verdant glory and rich plumage.

No matter where we may live, in or out of a big city, east or west, north or south, inland or by the sea, we are sure to find, within an accessible distance, some spot that is given over to the fern family, and if we are careful we can get new plants for our rockery or shady corner without injuring the countryside in any way.



Hart's-tongue Maidenhair spleenwort



Common polypody Lady fern

Among the rocks by the seashore, in the green lanes, by the side of the meadow, on the moorland, by the banks of the brook or stream, in the ditches by the road, and among the shadows of the wood—all these are places where ferns may be found free and flourishing.

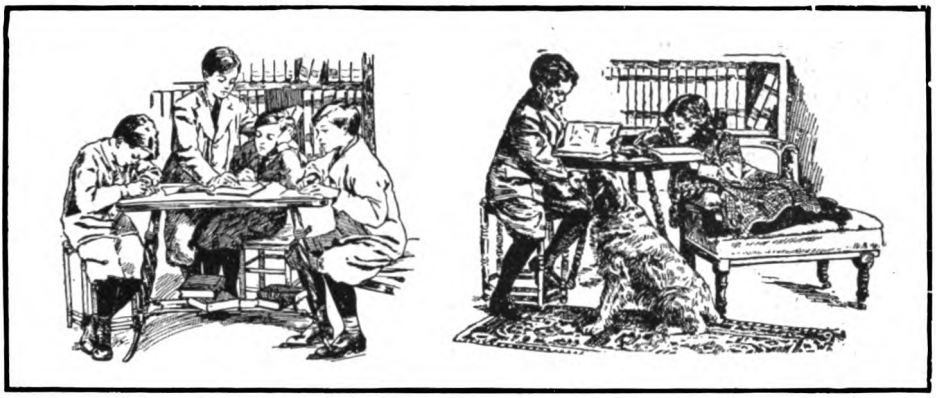
As equipment for a fern-hunt we need some pieces of brown packing-paper or newspaper to wrap the roots of our specimens in, a small garden fork and trowel, and, if we are intending to bring home very many plants, a bag or wicker basket.

In selecting plants, it is wise to take the smaller specimens; they can be removed more safely and easily than larger plants and they are easier to carry home. The earth round the plant selected should be loosened with the fork, and then the fern taken up with the trowel with as little disturbance to the roots as possible. Of course, it is essential that the whole of the roots should be taken, and so we must dig at some distance round and under the plant. The earth adhering to the roots should not be removed. Injury to the root will result in a dwarfed and sickly plant, when the fern is transplanted and made to grow in the garden.

Having freed our specimen, we should place a little damp moss round the roots, wrap the specimen up in paper, and place it carefully in the bag. If it is not convenient to plant them out on arriving home, we can keep them healthy and fresh for several days by laying them in a shady place and occasionally sprinkling the enwrapping moss with water. This plan enables us to bring home safely specimens gathered on a summer holiday.

Of course, if we want to get the best value out of our specimens, we should carefully note the situation and surroundings of each, and try to reproduce these as nearly as possible in the garden.

Rock ferns are more difficult to gather, and, in order not to disturb the roots, it is often necessary to bring home with us a piece of the rock in and round which are the delicate roots.



STORIES AND PLAYS

MASTER SELF

THERE was once a lit-tle boy," said Mam-ma, "and he loved Some-bod-y ver-y much. It is n't a ver-y large Some-bod-y, but it has bright blue eyes and curl-y hair."——"Why, it 's me!" said Char-lie. "It 's me, my-self."

"So it is," said Mam-ma, laugh-ing. "And it 's 'Mas-ter Self' whom Char-lie loves best. He even does n't love Sis-ter so much as 'Mas-ter Self.' So he keeps all his pret-ty toys and does n't give them up. He loves 'Mas-ter Self' bet-ter than Mam-ma, for when Mam-ma says 'Go to bed,' and 'Mas-ter Self' says 'No,'—Char-lie likes best to please that naught-y 'Mas-ter Self.'"

"I wont please 'Mas-ter Self,' said Char-lie, and he kissed Mam-ma, and said "Good-night." Next day, Mam-ma gave Char-lie a bright, new ten-cent piece, and said he might go with Nurse to buy some can-dy.

When Nurse and Sis-ter were read-y, and Char-lie had taken his lit-tle stick, they set out. Char-lie was think-ing. He was think-ing ver-y much, and he was say-ing to him-self: "I don't love 'Mas-ter Self.'"

He walked qui-et-ly by Nurse's side. Now and then he looked at the mon-ey in his hand; it was ver-y bright and ver-y white. It seemed a long way to the can-dy store.——"What will you buy, Char-lie?" asked Nurse.

"Some can-dy for my-self," said Char-lie, as they reached the Park.

"Keep close to me while we cross the road," said Nurse; but just then Char-lie pulled her dress and whis-pered: "Look, Nurse! Look there!" and Nurse saw a lit-tle girl stand-ing near a tree, a-lone and cry-ing.

"What's the mat-ter with her, Nurse?" asked Char-lie.

"I'll ask her," said Nurse. "What are you cry-ing for, dear?"

But the lit-tle girl on-ly cried the more, and Char-lie went close to her and said: "What's the mat-ter, lit-tle girl?"

The lit-tle girl could not speak, she was sob-bing so much. "Don't cry," said Char-lie, in great dis-tress. "It makes me want to cry too."

"Oh, dear! Oh, dear!" said the lit-tle girl. "I have lost my mon-ey! All my mon-ey." But soon she be-gan to tell Nurse how it was. She was go-ing to get some bread, and she had the mon-ey in her hand,—"and," said she, "a boy pushed me, and I fell, and lost my ten-cent piece, and I can't buy the bread, and Moth-er will be so an-gry."

"I'm glad I did n't lose my piece," said Char-lie, squeezing it hard.

"I am ver-y sor-ry for you," said Nurse. "If I were you, I 'd run home and tell Moth-er."

"I can't! I can't!" cried the lit-tle girl. "It was all Moth-er had, and we 're so hun-gry!"

Char-lie held his mon-ey tight-ly. What was he think-ing of, all the time? He was say-ing to him-self: "I don't love 'Mas-ter Self.'" He pulled Nurse's dress, and said: "Nurse, can't you give the lit-tle girl some mon-ey?"

"I have n't my purse, dear," said Nurse.

The lit-tle girl moved a-way, cry-ing. Char-lie walked be-side Nurse. They were near the can-dy store. He could see the sweets in the win-dow, —sticks and balls and creams! Char-lie turned his head. He saw the lit-tle girl look-ing back too. She was still cry-ing. Char-lie pulled Nurse's dress. "Nurse," he said, "I want to turn back."

"What do you want to turn back for?" asked Nurse. "Here is the store."

Char-lie raised him-self on tip-toe to get near-er to Nurse's ear, and whis-pered:

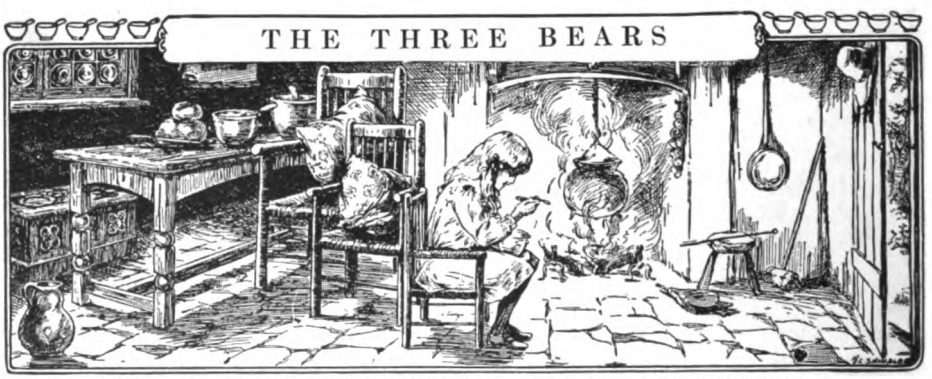
"I want to please the lit-tle girl and not 'Mas-ter Self'!"

Nurse knew what he meant. She turned back. Char-lie looked once more at the can-dy store, then he ran a-cross the street. When he came close to the lit-tle girl, he held out his bright ten-cent piece and said: "It is for you, and not for 'Mas-ter Self'!"

The lit-tle girl stopped cry-ing and be-gan to smile; then she tried to say "Thank you," to Char-lie; but Nurse said: "Run, now, and buy your bread," and she ran off, aft-er look-ing back to nod and smile at Char-lie.

But Char-lie was even hap-pi-er than she. He walked brisk-ly home and sat on Mam-ma's lap, and told her all a-bout it. Mam-ma kissed him, and said: "Is n't Char-lie hap-py now?"

And Char-lie said: "Yes; be-cause I did n't please 'Mas-ter Self.'"



GOLDILOCKS TOOK UP THE SPOON AND ATE UP ALL THE BABY BEAR'S DINNER

THREE bears lived in a house in a wood. There was the father bear, the mother bear, and the baby bear. The first was a great big bear, the second was a middle-sized bear, and the third was a tiny wee bear. In the kitchen was a table, and beside the table there were three chairs. The first was a great big chair, the second was a middle-sized chair, and the third was a tiny wee chair.

One day the three bears went out for a walk. Before they started

mother bear prepared the dinner, and poured it into three basins. The first of these was a great big basin, the second one was a middle-sized basin, and the third one was a tiny wee basin.

While they were out a little girl named Goldilocks passed by that way, and looked in at the window. She was very cold and hungry, and the bread and honey in the basins looked very tempting. So she pushed open the door and walked in.

"How good it smells!" she said. And she sat down in the great big chair. But it was much too large for her. So she tried the middle-sized chair, but that was not high enough; so she sat down in the tiny wee chair, which just fitted her.

She took up the spoon and soon ate up all the little baby bear's dinner.

When she had finished she began to feel very tired, and thought she would like to lie down. So she went upstairs into the bedroom, where she found three beds. The first was a great big bed, the second was a middle-sized bed, and the third was a tiny wee bed. First she tried the big bed, but it was much too big. So she got out again and tried the middle-sized bed. But *that* was too big, so she jumped into the tiny wee bed and fell fast asleep.

Soon the bears came back, and as their walk had made them very hungry they went straight up to the table.

"Someone's been sitting in my chair," cried the great big bear in a great big voice.

"Someone's been sitting in my chair," cried the middle-sized bear in a middle-sized voice.

"And someone's been sitting in *my* chair," cried the tiny wee bear in a tiny wee voice.

Then they looked into their basins.

"Someone's been tasting my dinner," cried the great big bear in a great big voice.

GOLDILOCKS RAN DOWN THE STAIRS AS FAST AS SHE COULD AND ESCAPED INTO THE WOODS

"Somebody's been tasting my dinner," cried the middle-sized bear in a middle-sized voice.

"And somebody's been tasting *my* dinner and eaten it all up," cried the tiny wee bear in a tiny wee voice.

"Who is it?" cried all the bears together. And they all ran upstairs.

The great big bear ran to the great big bed.

"Somebody's been lying in my bed," he cried.

The middle-sized bear ran to the middle-sized bed.

"Somebody's been lying in my bed,' she cried.

And the tiny wee bear called out in a tiny wee voice:

"And somebody's been lying in *my* bed—and, oh, here she is!"

Just at that moment Goldilocks woke up and saw the three bears looking angrily at her. She was so frightened that she jumped up and ran down the stairs as fast as ever she could, and out of the house into the wood, and they never saw her again.

BRER RABBIT AND TAR-BABY

BRER FOX was always trying to catch Brer Rabbit; but Brer Rabbit was mighty pert and spry, and he never let Brer Fox catch him. So Brer Fox pretended to be friendly, and asked Brer Rabbit to come to dinner with him. But Brer Rabbit did not come; he knew what was going to be eaten at that dinner. Brer Fox then thought of something else. He went to work and got some tar and some turpentine, and fixed up a thing which he called a Tar-Baby. He set up this Tar-Baby by the road near Brer Rabbit's house, and laid low beneath the bramble-bushes near by to watch what would happen.

By and by Brer Rabbit came prancing along, lippity-clippity, clippity-lippity, as saucy as a jay-bird. When he saw Tar-Baby he sat up on his hind legs in astonishment.

"Good-morning," says Brer Rabbit, very politely and nicely. "Fine weather this morning," says he.

Tar-Baby said nothing, and Brer Fox he laid low.

"Are you deaf?" said Brer Rabbit. "I can shout if you are."

And he shouted. But Tar-Baby kept on saying nothing; and Brer Fox he winked his eye slowly, and laid low.

At last Brer Rabbit raised his fist and hit Tar-Baby on the side of her head. And there his fist stuck in the tar, and he couldn't pull it away.

"Howdydo?" says Brer Fox, coming out of the bushes. "You seem rather stuck up, Brer Rabbit, this morning."

"Let me go, or I'll strike you again!" says Brer Rabbit. And he hit out with his other hand, and that stuck on Tar-Baby.

Brer Rabbit kicked out angrily with his feet, and they got stuck on Tar-Baby. Then he butted her with his head, and his head also got fixed.

"Howdydo?" says Brer Fox, coming out of the bushes, and looking as innocent as a dicky-bird. "You seem rather stuck up, Brer Rabbit, this morning."

And then Brer Fox rolled about the ground and laughed.

"I expect you'll come to dinner with me now, Brer Rabbit," says he. "We're going to have some nice roast rabbit. You won't play any more tricks on me. You're too saucy by far.

Who asked you to strike up an acquaintance with this Tar-Baby? Now you're going to have a warm time, as soon as I can get some firewood together."

Then Brer Rabbit began to talk mighty humble.

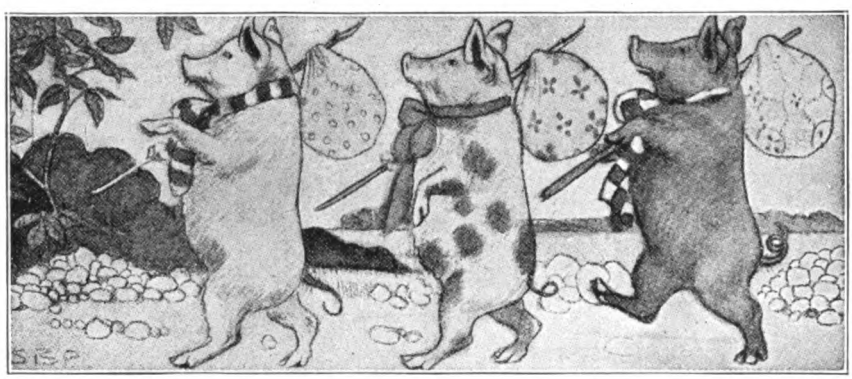
"I don't care what you do with me, Brer Fox," says he, "so long as you don't fling me on those prickly bramble-bushes."

"It's too much trouble to light a fire," says Brer Fox. "I'll have to hang you."

"Hang me, or drown me!" says Brer Rabbit. "I don't mind. But for pity's sake don't fling me on those prickly bramble-bushes."

But Brer Fox wanted to hurt Brer Rabbit as much as he could, so he took him by the hind legs and pulled him off Tar-Baby, and flung him right into the middle of the prickly bramble-bushes. There was a considerable flutter where Brer Rabbit struck the bushes, and Brer Fox wanted to see what was going to happen. By and by he heard someone calling up the hill, and there he saw Brer Rabbit sitting on a log, combing the tar out of his hair with a chip of wood.

"I was bred and born in a bramble-bush, Brer Fox—bred and born in it," says Brer Rabbit, with a laugh. And with that he skipped off home as lively as a cricket.



THE THREE LITTLE PIGS

ONCE upon a time, three little pigs went out into the world to seek their fortunes. The first little pig had not gone far before he met a man who was carrying a bundle of straw.

"If you please," said the little pig, "will you give me some of that straw to make me a house?"

"With pleasure," replied the man.

Away went the little pig with the straw, and built his house.

Now, an artful old wolf who lived close by determined to have the little pig for supper. So when it became dusk he went up to the little straw house and called out:

"Little pig, little pig, may I come in?"

But the little pig knew his voice, and said:

"No, no; by the hair on my chinny, chin, chin!"

"Ho, ho!" cried the wolf. "Then I'll puff and I'll blow till I blow your house in."

And he puffed and he blew, and he puffed and he blew till the house fell down. Then he sprang inside, pounced on the little pig, and gobbled him all up.

The second little pig met a man carrying some sticks.

"If you please," said the little pig, "will you give me some of those sticks to make me a house?"

"With pleasure," replied the man.

Away went the little pig with the sticks, and built himself a cozy house.

That night the wolf came to the door.

"Little pig, little pig," cried the wolf, may I come in?"

"No, no," replied this little pig, as the other one had done; "by the hair on my chinny, chin, chin!"

"Ho, ho!" cried the wolf in a rage. "Then I'll puff and I'll blow till I blow your house in."

And he puffed and he blew, and he puffed and he blew till the house fell down. Then he sprang inside, pounced on the poor little pig, and gobbled him all up.

But the third little pig was exceedingly wide awake the morning he set out on his travels. This little pig went on till he saw a man carrying bricks.

"If you please," said the little pig, "will you give me some of those bricks to make me a house?"

"With pleasure," replied the man.

Away went the little pig with the bricks, and built his house.

Soon the old wolf came along that way, and knocked at the door.

"Little pig, little pig, may I come in?" cried he.

"No, no; by the hair on my chinny, chin, chin!"

"Then I'il puff and I'll blow till I blow your house in!"

But the house was made of bricks, and the old wolf he puffed and he blew, and he puffed and he blew, and still the house stood firm. At last he went away in a rage; but presently he came back again.

"Little pig, little pig, I know a field just down the lane where there are such fine turnips. I'll call for you in the morning and show you the way."

The next morning when the wolf called out: "Are you ready, little pig?" the little pig replied: "Dear me, how late you are! I've been back an hour or more. I'm sure I'm much obliged to you; they were fine turnips!"

The wolf was furious; but, pretending he did not mind, he said, quite pleasantly:

"Do you like apples? I know an orchard down the lane where the trees are covered with fruit. I'll call for you in the morning, and show you the way."

The next morning the wolf got up very early, and walked round to the little pig's house. But the little pig must have got up earlier still, for when the wolf arrived he found him out.

The wolf hurried off to the orchard; but the little pig saw him coming, and climbed up into a tree.

"These are indeed fine apples," he called out, as the wolf came up to it. "Just try this one." And he threw the apple as far away as he could into

THE WOLF CAME BACK AGAIN TO THE HOUSE

"Dear me, how late you are!" said the little pig when he saw the wolf. "I've been back an hour or more. I'm sure I'm much obliged to you: they were fine turnips!" The wolf was furious, but pretended he did not mind.

some long grass. Then, while the wolf was hunting for it, the little pig scrambled down the tree, and ran home.

The wolf did not like being beaten, so the next morning he went again to the little pig's house, and said:

"Little pig, little pig, there's going to be a fair on the village green this afternoon. You come along with me, and we'll both have a fine time. I'll call for you at exactly three o'clock."

The little pig said nothing, but at half past two he started off for the fair. He bought a churn, and was rolling it home, when he saw the wolf in the distance. Quick as lightning the little pig jumped into the churn to hide, and set it rolling down the hill. The hill was steep, and the churn came flying along at such a speed that the wolf became frightened, so he turned back and ran home as fast as he could.

Some hours later, when he felt braver, he went to the little pig's house.

"I was just on my way to call for you this afternoon," he shouted out, "when I met the most awful thing rolling down the hill all by itself. It gave me a horrible fright, I assure you. There must have been a witch inside."

The little pig burst out laughing, and he laughed so loud and he laughed so long that the old wolf got annoyed.

"I was the old witch," said the little pig, as soon as he could speak. "I spied you a long way off, and I jumped inside to save my skin."

This so enraged the wolf that he jumped up on to the roof and began sliding down the chimney. But it was baking day, and the little pig had made a huge fire. Down, down, down slid the wolf; there was nothing to save him. He sank right down into the fire, and was burned to cinders. And that was the end of the old wolf.

THE STORY OF THE DAYS

SUNDAY, MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY, SATURDAY

HAVE you ever met Mr. and Mrs. Day? A more useful family you will never meet from one year's end to the other. They are, in fact, the best servants of the human race, and do as much work in their time as anything or anybody on the face of the earth. We must make their acquaintance.

The seven-roomed house in which they live is called "The Week," and it stands in Month Street, which is one of the twelve roads running through Year Town in the wonderful country of Time. We will enter this house and go through the seven rooms together. Mr. Day lives in one room, Mrs. Day in another, and their five children have each a room to themselves. But they are only separated from each other by walls of Sleep, and they talk to each other through the telephone of Dreams.

Now, this is the first room, occupied by Mr. Day, who does less work than the rest of the family, but who is very far from being idle. He puts on a surplice and holds Church services, and he also has to provide the whole of the human race with amusements and recreations. He is the father of the family, and he is known by the name of Sun Day.

"Hullo, Mr. Sun Day! How are you? Glad to see you. But everybody's that, eh? There is no member of your family quite so popular as you are! Come, I hope you are glad to see me, too. I've brought a little friend with me, who wants to know how you

AGES AGO MEN WORSHIPED THE SUN AND CALLED THE FIRST DAY OF THE WEEK AFTER IT

got your name, and to hear something of your history. Do you feel like talking for a few moments?"

"How I got my name? Well, that's an old story, that is. How I got my bad name isn't nearly so old; and how I am getting my good name is quite a new story. Nevertheless, just to oblige your young friend, I'll run the whole three stories into one, and begin with the old one. Far back in the history of the world, young friend, people could see nothing so wonderful, nothing so beautiful, and nothing so useful as the sun. They had in them what is called the *instinct of worship*—that is to say, they had a feeling that there was Something greater, stronger, and more glorious than themselves—Something that they ought to fear, reverence, and worship. The sun seemed to these first people the token or sign of that Something, and they worshiped it. The sun, in fact, became the visible expression of God. Now, when the world got wiser, and men and women knew more about the true God, they still kept the old idea of the heathen in their heads, and called the Christian Sabbath—which means the day of rest—Sunday. They no longer worshiped the sun, but they called the first day of the week after it, and that is how I got my name.

"People loved me then, and I gave rest, and pleasure, and festivity to hundreds of generations. Well, as time passed on, people began to make me anything but a sun-day; they made me a black day. Children were not allowed to play; books and games were put away and locked up in cupboards as something wicked; and all my precious hours were spent in gloom and solemnity.

"Then it was that I got a thoroughly bad name. People said Sunday was the gloomiest day in the week; they ate too much, and sat about yawning and

grumbling. Just lately I've reminded them that the Founder of Religion once said: The Sabbath was made for man, not man for the Sabbath. They don't quite understand just yet what that means. Some of them are noisy and wild and foolish on the Sabbath; they have gone to the other extreme. But it will come right soon. People will use me for rest of body and mind in a proper way, and my good name will be restored.

for Moon. She is really Moon Day, the day sacred to the wife of the Sun. In ancient times people called the goddess of the moon Diana, and temples were built for her in nearly every quarter of the world. They used to think that Phœbus Apollo, the Sun God, drove his flaming chariot across the sky by day, and that Diana drove her silver chariot through the sky by night. They loved Diana because she was gentle and beautiful. Woods

MONDAY WAS SACRED TO THE MOON, THE WIFE OF THE SUN, WHO WALKED IN THE WOODS

"Well, let us pass to the next room and see what Mrs. Day will tell us."

"I've no time to stay to gossip. I'm a busy woman. Everybody knows that I'm the busiest day in the week. It's coming after Sunday that does it. Ah, he's a lazy fellow, my husband is. The mess I have to clear up after him! I don't believe in holidays—except Easter Mondays. Let everyone do his work."

"We mustn't interrupt her," said Mr. Day. "Her name of Mon is short

were sacred to her because she could be seen walking through them. Round cakes were made on her feast day, with candles stuck round them.

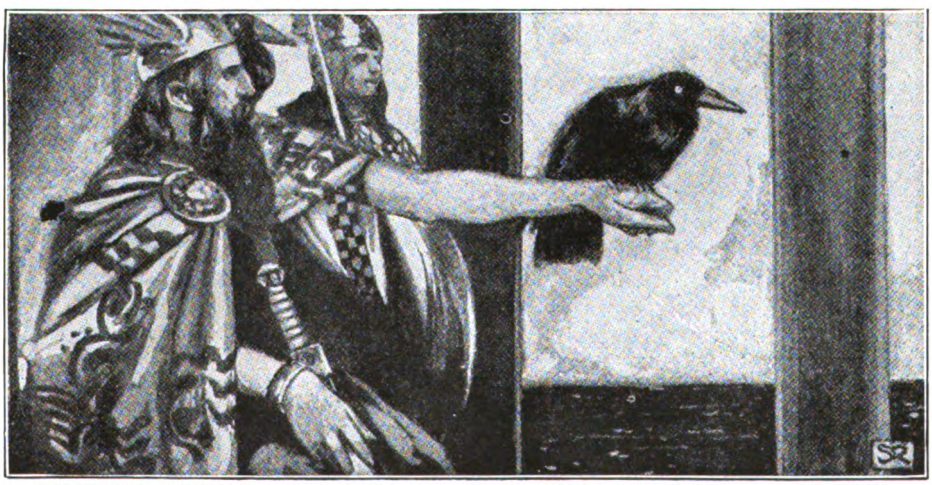
And now we must peep into the room of Mr. and Mrs. Day's eldest son, Master Tues Day. You observe that he has only got one hand, and the story of how he lost his other hand is the story of how he came by his name.

The Norsemen had a god of war named Tyr, and when a terrible wolf-spirit, named Fenris, had to be cap-

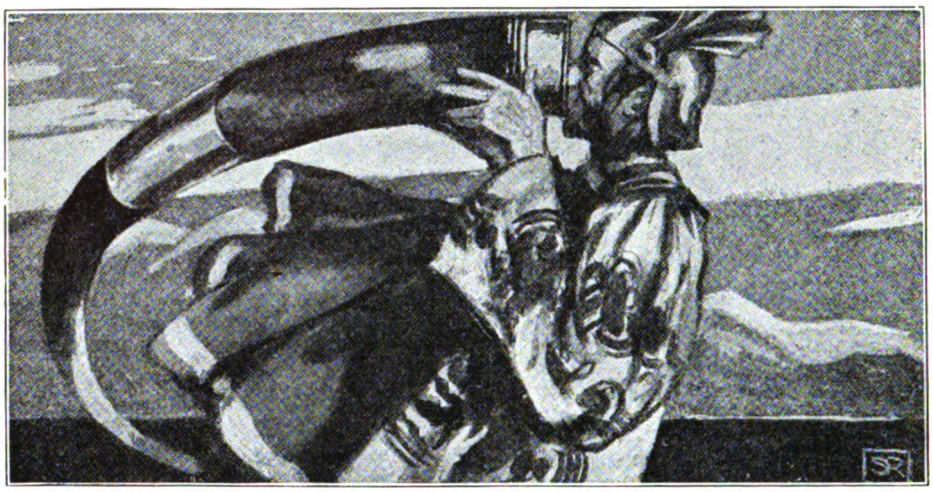
TYR, THE GOD OF WAR, CAPTURED THE WOLF-SPIRIT, AND TUESDAY IS NAMED AFTER HIM

tured, because he was troubling the whole earth, it was Tyr who undertook the dangerous venture. The spirits of the mountains had made a chain out of the hardest things in the world to find—the footsteps of a cat, the beards of women, the roots of stones, the breath of fishes, the nerves of bears, and the spittle of birds. This strange chain could not be broken, and with it Fenris was to be bound.

But Fenris would not allow even this soft-looking chain to be put round his neck, and said he would only suffer it if the gods would promise to take it off again, and would send a god to put his hand in the wolf's mouth. Tyr was the only god brave enough to volunteer. He put his hand in the mouth of Fenris, and Fenris was bound; then, in his rage at being captured, he bit off the hand of the god. It is curious that the French name for Tuesday is Mardi—that is, the day of Mars, who was also a god of war like the Norseman's Tyr, who gives us Tyr's Day, or Tuesday. The second son of Mr. and Mrs. Day is named after



WEDNESDAY IS CALLED AFTER WODEN, WHO SENT RAVENS ROUND THE WORLD FOR NEWS



THE MORE THAT THOR, THE GOD OF THURSDAY, TRIED TO DRAIN THE HORN, THE MORE IT FILLED

Woden, or Odin, the greatest god of the Scandinavians. Woden lived in a palace built entirely of gold and silver, which was called Valhalla. Two ravens stood on his shoulders, and when he wanted news of the world he sent these ravens to fly round the earth and bring him intelligence of everything they saw and heard.

Round about him stood maidens with helmets, and spears, and shields, and these maidens, named Valkyries, were sent down to earth to bring the souls of heroes slain in battle to feast with Woden in Valhalla. While they feasted, Woden listened to their stories and drank mead. He never ate anything himself. Our friend Wednes Day is rather odd and capricious in his habits. He sends his Valkyries to bring boys and girls into Valhalla for a half-holiday, but leaves the rest of the world hard at work. But he is a good fellow, and everybody likes him. He lives in the middle of the house and seems to be saying all day long:

"Work away; work away! Sunday will soon be here again."

FRIDAY WAS NAMED AFTER FREYA, THE WIFE OF WODEN, SO THAT SHE MIGHT NOT BE JEALOUS

And now here we are at the fifth room, occupied by Master Thurs Day. Isn't he a big strong, vigorous fellow? If ever you have a hard bit of work to do, start at it on Thursday—the day of strength and power. Thurs Day gets his name from Thor, the strongest of all the Scandinavian gods. Thor had a hammer which no man could lift, a pair of iron gloves, and a belt which, when it was fastened round him, doubled his great strength. But once the mighty hammer was lost, and a giant named Thrym hid it. He said he would only give it up if the goddess Freya would marry him. Thor disguised himself in Freya's dress and went to visit the giant. He received the hammer, and slew Thrym and all the other giants.

The sixth room belongs to Mr. and Mrs. Day's only daughter, Fri Day, named after the goddess Freya, who refused to marry Thrym. How this female Day got her name is rather sad. Woden was Freya's husband, Thor her son; and it was only because she might be jealous that our ancestors named a day after her when they had given one to Woden and one to Thor. However, Friday is a very sacred day, although some superstitious people think it is a day of ill-luck.

And now here is another half-holiday room, Satur Day, who gets his name from the Roman god Saturn, a god who ate his own children. For us Saturday is one of the pleasantest days in the week, although some of the games and feastings of our Saturday crowds remind us of those terrible Saturnalia which disgraced Rome.

SATURDAY IS THE DAY OF SATURN, IN WHOSE HONOR THE ROMANS USED TO FEAST AND DRINK

AURORA

THE STORY OF APOLLO AND LETO

In very early days people, as we now know, had very little true knowledge of the sun and moon and stars; of the sea and the winds and the storms. Indeed, they knew as little of these as they did of the Creation.

To them it was all very, very wonderful, and they thought out wonderful stories to account for what they saw on the earth and in the skies above them.

They knew that when the sun shone, the green grass sprang up; the flowers came; the trees were loaded with fruit, and food was plentiful.

So they began to say to each other, "The sun is our Good Spirit, the Loving One who watches over us and takes care of us."

And so it came about that, by and by, these early people became sun worshippers; they prayed and offered sacrifices to the sun; and after a long time there grew up many stories of the sun.

Here is a story of the Sun God as the early Greek people used to tell it to their little boys and girls:

Once there was only darkness upon the earth. Then a beautiful woman, Leto, came wandering up and down the dark earth, carrying in her arms a beautiful, sunny-haired baby boy.

"Let us dwell here in your land," said Leto to the people. "Let me rest here upon your hillsides. Behold, I bring the light of day to you," she pleaded. "I will bring you power and wealth and rich harvests and beautiful flowers, for the Sun God shall abide in the land which gives me shelter."

"We know," said the king of Crete, "that all these things are promised wherever the Sun God shall dwell; but we are afraid of you; we fear your dark and terrible beauty."

"We know that such a god is promised," said also the king of Athens; "and gladly would our people welcome him. But how are we to know that you are the mother of this radiant god? No, Leto, we dare not open our gates to you. Go hence; we await the coming of Apollo."

And so from land to land Leto wandered, till at last she came to the island of Delos. It was but a barren little island in the midst of a great blue sea. Its shores were rocky; its fields were bare; its mountains black and grim and wild.

And in the island dwelt a king whose people were poor and ignorant. He had neither wealth nor power; and scarcely was the name of this king known among the people of the lands that bound the sea.

"Delos, Delos," cried Leto, when she came to this rocky shore, "listen to the voice of Leto. Give me welcome and I will bring glory and great wealth and power to your people. The island of Delos shall be a temple; and to its altars people from all nations shall come, bringing their offerings. Welcome me, and my child, the Sun God, Apollo, will love you and will abide forever in your land."

Then said the king of Delos, "Leto, it cannot be that the Apollo would care to dwell upon our barren island. Little have we to offer this glorious child of thine; for we have but a rocky soil. The mountains are black and rough. Our people are fierce. They know little of the wealth and glory of other lands. A weary home would this be for a child like the fair Apollo."

"O king of Delos! can you not believe that the promise I make shall be fulfilled?" said Leto.

Then the good king said, "Even though the child shall not remain in this land of Delos; and even though this island has little to offer either to gods or men, let it not be said that we failed to welcome any stranger who came to our shores. Enter, Leto, and rest in Delos."

Then Leto entered. The darkness grew deeper and deeper upon the island and there was stillness even upon the seas. The king and all his people slept, but happy dreams, however, came to them; dreams of glory and power; dreams of beauty and greatness; dreams of light and of a splendor which the earth had never known.

By and by the king awoke. Upon the mountain tops he saw a new, strange light and brightness shining behind the great, dark pillars of rock. Gradually the light grew brighter. And behold, there upon the mountain top stood Apollo, the Sun God, his hair shining like gold in the fresh new light of day.

He smiled down upon the plain, and the plain blossomed into color. Grains grew and waved their happy blossoms in the wind; flowers sprang forth—flowers of richest color and sweetest odors.

For Apollo, the Sun God, had come! He had made his home in Delos; and there was joy in the island from shore to shore.

Under a toadstool
Crept a wee Elf,
Out of the rain,
To shelter himself.

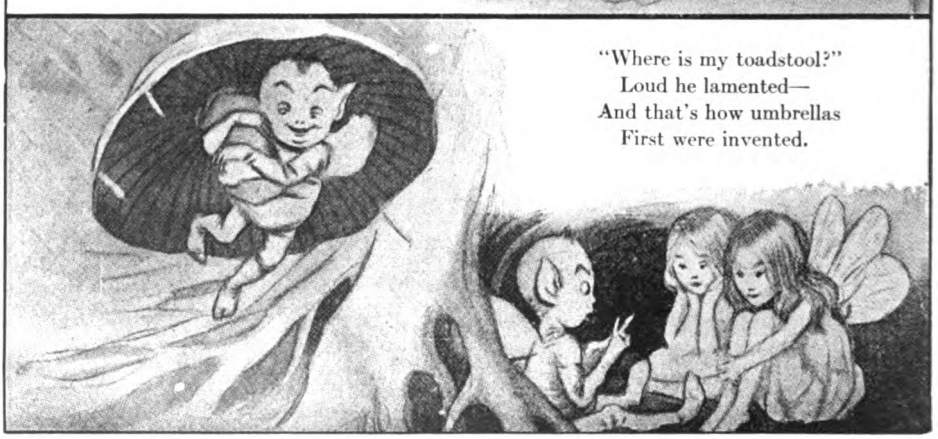
Under the toadstool,
Sound asleep,
Sat a big Dormouse
All in a heap.

Trembled the wee Elf,
Frightened, and yet
Fearing to fly away
Lest he got wet.

To the next shelter—
Maybe a mile!
Sudden the wee Elf
Smiled a wee smile.

Tugged till the toadstool
Toppled in two.
Holding it over him,
Gaily he flew.

Soon he was safe home,
Dry as could be.
Soon woke the Dormouse—
"Good gracious me!"

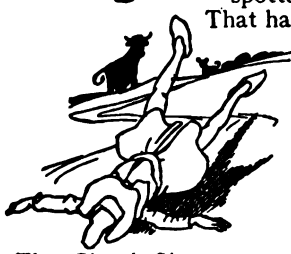


"Where is my toadstool?"
Loud he lamented—
And that's how umbrellas
First were invented.

SIMPLE SIMON met a pieman
Going to the fair;
Says Simple Simon to the pieman:
"Let me taste your ware."
Says the pieman unto Simon
"First give me your penny!"
Says Simple Simon to the pieman:

"Indeed, I have not any."

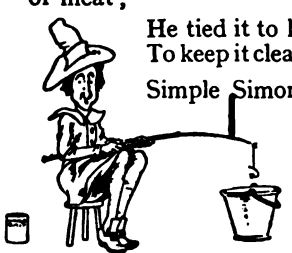
He went to catch a dicky bird,
And thought he would not fail,
Because he had a little salt
To put upon his tail
He went to ride a spotted cow
That had a little calf;



She threw him down upon the ground,
Which made the people laugh.

Then Simple Simon went a-hunting
For to catch a hare;
He rode a goat about the street,
But could not find one there.
Simple Simon went to town
To buy a piece of meat;

He tied it to his horse's tail
To keep it clean and sweet.



Simple Simon went a-fishing
For to catch a whale,
And all the water he had got
Was in his mother's pail.

He went to take a bird's nest—
'Twas built upon a bough,
A branch gave way, and Simon fell
Into a dirty slough.
He went to shoot a wild duck,
But the wild duck flew away,
Says Simon "I can't hit him
Because he will not stay"

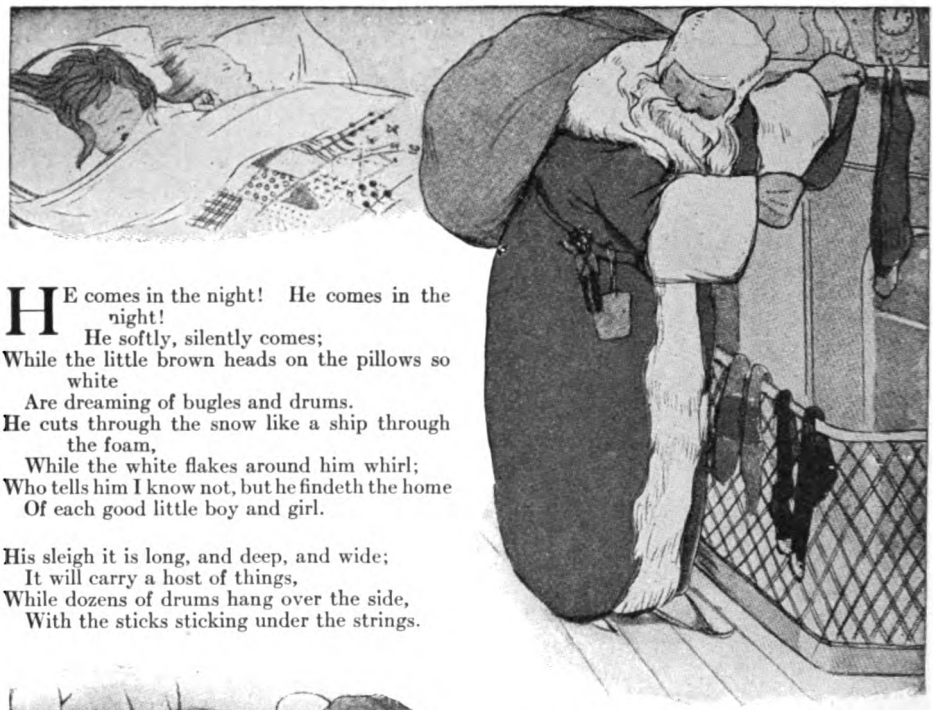
Once Simon made a great snowball,
And brought it in to roast;
He laid it down upon the fire,
And soon the ball was lost

He went to slide upon the ice,
Before the ice would bear
Then he plunged in above his knees,
Which made poor Simon stare.

Simple Simon went to look
If plums grew on a thistle,
He pricked his finger very much,
Which made poor Simon whistle.

He washed himself with blacking ball,
Because he had no soap;
And then said to his mother:
"I'm a beauty now, I hope."

He went for water in a sieve,
But soon it all ran through.
And now poor Simple Simon
Bids you all adieu.



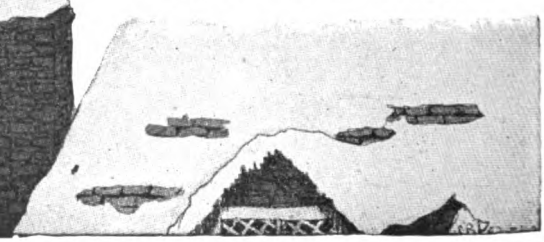
HE comes in the night! He comes in the night!
He softly, silently comes;
While the little brown heads on the pillows so white
Are dreaming of bugles and drums.
He cuts through the snow like a ship through the foam,
While the white flakes around him whirl;
Who tells him I know not, but he findeth the home
Of each good little boy and girl.

His sleigh it is long, and deep, and wide;
It will carry a host of things,
While dozens of drums hang over the side,
With the sticks sticking under the strings.

And yet not the sound of a drum is heard,
Not a bugle blast is blown,
As he mounts to the chimney-top like a bird,
And drops to the hearth like a stone.

The little red stockings he silently fills
Till the stockings will hold no more;
The bright little sleds for the great snow hills
Are quickly set down on the floor.
Then Santa Claus mounts to the roof like a bird,
And glides to his seat in the sleigh;
Not the sound of a bugle or drum is heard
As he noiselessly gallops away.

He rides to the East, and he rides to the West,
Of his goodies he touches not one;
He eateth the crumbs of the Christmas feast
When the dear little folks are done.
Old Santa Claus doeth all he can,
This beautiful mission is his;
Then, children, be good to the little old man,
When you find who the little man is.



THE BATTLE OF BLENHEIM

The great battle of Blenheim, a town on the River Danube, was fought on August 13th, 1704, Marlborough commanding the English army allied with the Germans against the French and Bavarians. It was "a famous victory," but 37,000 lives were lost. The poem was written by Robert Southey, who was made Poet Laureate of England in 1813, though we cannot call him a great poet. By means of a very simple talk between an old man and a little boy and girl, who had found the skull of one of the slain soldiers a hundred years after the battle, the poet shows us what a terrible curse is war.

It was a summer evening,
Old Kaspar's work was done,
And he before his cottage door
Was sitting in the sun;
And by him sported on the green
His little grandchild, Wilhelmine.

She saw her brother Peterkin
Roll something large and round,
Which he beside the rivulet
In playing there had found;
He came to ask what he had found,
That was so large and smooth, and round.

Old Kaspar took it from the boy,
Who stood expectant by;
And then the old man shook his head,
And with a natural sigh—
"'Tis some poor fellow's skull," said he,
"Who fell in the great victory.

"I find them in my garden, for
There's many here about;
And often when I go to plough
The ploughshare turns them out;
For many thousand men," said he,
"Were slain in that great victory."

"Now tell us what 'twas all about,"
Young Peterkin he cries,
And little Wilhelmine looks up
With wonder-waiting eyes.
"Now tell us all about the war,
And what they fought each other for."

"It was the English," Kaspar cried,
"Who put the French to rout;
But what they fought each other for
I could not well make out.
But everybody said," quoth he,
"That 'twas a famous victory.

* * * * * *

"They say it was a shocking sight
After the field was won;
For many thousand bodies here
Lay rotting in the sun:
But things like that, you know, must be,
After a famous victory.

"Great praise the Duke of Marlbro' won,
And our good Prince Eugene."
"Why, 'twas a very wicked thing!"
Said little Wilhelmine.
"Nay, nay, my little girl," quoth he,
"It was a famous victory!

"And everybody praised the Duke
Who this great fight did win."
"But what good came of it at last?"
Quoth little Peterkin.
"Why, that I cannot tell," said he,
"But 'twas a famous victory."

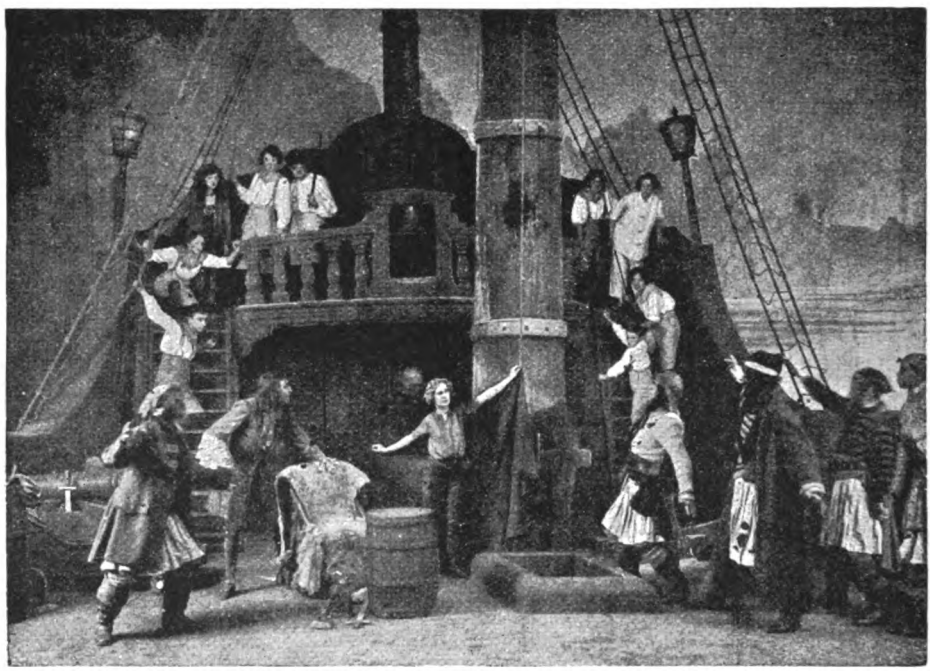
"'TIS SOME POOR FELLOW'S SKULL," SAID HE, "WHO FELL IN THAT GREAT VICTORY."

HOW PETER PAN FOUND HIS SHADOW

THERE was once upon a time a little girl named Wendy Moira Angela Darling. She lived in a house with her brothers, John Napoleon Darling and Michael Nicholas Darling. This house was an ordinary house of brick and slates, but one thing about it was quite extraordinary. It contained a Newfoundland dog whose name was Nana, and this dog acted as nurse to the three children.

Nana was so clever that he never allowed the children to put on a flannel night dress before it was aired at the fire; and he knew how to turn on the hot water when it was bath-time; and however the children might cry that they would not be bathed, or that they would not go to bed, Nana always insisted that they should.

Now Mrs. Darling loved Nana, and she had a particular reason for keeping this brave and powerful dog as the children's nurse. One night, on visiting the nursery, she had seen a strange flitting shape moving quickly to and fro in the dim glow of the nightlight. At sight of Mrs. Darling this shape rushed to the window. Mrs. Darling darted towards it. Just as it sprang into the night Mrs. Darling pulled down the window with a bang. The shape escaped; but something fell on the floor at Mrs. Darling's feet. It was the shadow of this strange, flitting creature. Mrs. Darling put the shadow in a drawer; but she felt very nervous for the safety of the children. She feared that the shape might come back and do them some dreadful harm. The only comfort she had was the presence of Nana in the nursery. The big dog, she thought, would protect her children from all danger. But one night Mr. Darling was rather cross,



Peter Pan saves the children from the pirates

and he said it was ridiculous to have a dog for a nurse; and he got so cross at last that he said Nana should sleep in a kennel in the yard. Mrs. Darling pleaded; the children cried; Nana barked. Mr. Darling, however, was extremely cross, and Nana was led away to the yard, moaning and growling.

That night the window was thrust open, and into the room glided and skipped the mysterious shape.

"Where is my shadow?" it cried; while Nana barked furiously outside.

"I can't be happy without my shadow. Tinker Bell, Tinker Bell, where is my dear little shadow?"

Instantly a spot of light flicked into the room, and sprang round the walls, and over the ceiling, and down the beds, and across the carpet, making a tinkling sound wherever it flitted and whenever it settled for a moment. This was the fairy Tinker Bell, a little female fairy. She told the shape where the shadow lay, and soon the drawer was open, the shadow pulled forth, and the shape skipped round the room with delight, singing, dancing, laughing in its joy, while Tinker Bell flashed round the room like a luminous butterfly. But, alas! when the shape tried to make the shadow stick on, it refused, and so all the delight went, and the shape burst into passionate tears.

Just at this moment Wendy awoke. She was not frightened, and asked the little shape why it was crying. Then she asked it its name, and the shape told her that it was Peter Pan. Wendy got needle and thread and stitched the shadow on to Peter Pan, and then Peter Pan danced with joy, for wherever he went the shadow followed him on the floor.

Peter Pan then told Wendy his story. He said that he lived in a place called Never-Never-Land, with a lot of little boys who had all been dropped out of their perambulators by careless nurses; and that they lived with fairies and would never grow up, but for always and always would remain happy boys in this enchanting Never-Never-Land.

He told her that when the first baby laughed, the laughter broke into little pieces, and each little piece became a fairy, and went dancing about the world. But whenever a child says

Statue of Peter Pan in Kensington Gardens, London

that it does not believe in fairies, then one of the fairies dies. Peter Pan said it was dreadful for a child to say it did not believe in fairies. There was only one other thing that made them sad, he said, and this was the want of a mother; all the boys in Never-Never-Land wanted to have a mother very much indeed. Wendy asked if there was not a little girl among them who could pretend to be their mother; but Peter Pan shook his head and answered that girls never dropped out of their perambulators, they were far too clever. This pleased Wendy, and she loved Peter Pan.

"Oh, Wendy," cried Peter, "come and live with us and be our mother!"

The two boys woke up. Peter Pan said he would teach them all to fly if Wendy would only come and be their mother. All this time Tinker Bell was tinkling angrily, and telling Peter Pan to come away at once. Tinker Bell loved Peter Pan, and was jealous of Wendy.

When the children heard that they could learn to fly, they were quite excited, and immediately began to spring in the air. But every time, they fell and sprawled on the ground, or bumped flat on the beds.

"You must think beautiful thoughts," cried Peter Pan; and, so saying, soared up gracefully into the air, and sailed noiselessly round the room.

Soon the children learned, and all began to fly round the room with cries of delight. Then the windows opened wide, and Peter Pan led the way into the night; and while Tinker Bell tinkled loudly and Nana barked warningly, the children soared towards the stars.

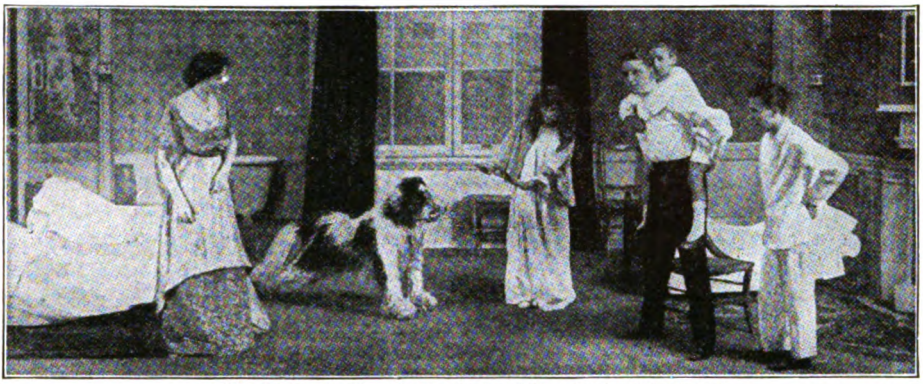
The boys in Never-Never-Land were beginning to get anxious about Peter Pan, who was their captain. He seemed to be a long time away, and they were frightened of wolves and pirates. While they were wondering what had happened to Peter, they saw what looked to them like a large white bird in the sky.

As they gazed at it, Tinker Bell suddenly shone on the trees, and, tinkling very loudly, told them that Peter Pan wanted them to shoot this bird at once. So they ran and got bows and arrows, and shot them into the air. Suddenly down fell—what do you think?—poor Wendy with an arrow in her breast. Jealous little Tinker Bell was responsible for this awful deed.

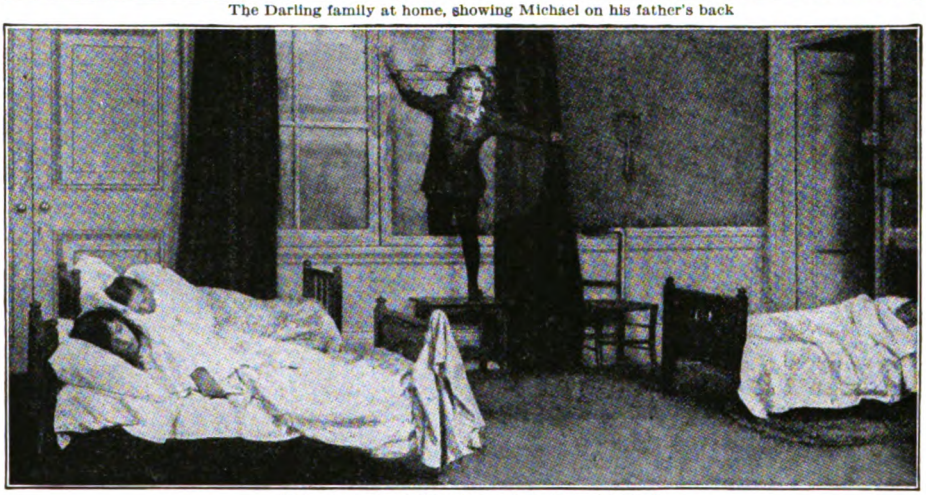
But she was not killed. Soon she revived, and then with her brothers round her, and Peter Pan holding her hand, she promised all the boys to be their mother. Then they set to, and built Wendy a funny little house, with the silk hat of John Napoleon Darling for its chimney-pot; and everybody was wonderfully happy, except Tinker Bell, who was more and more jealous of Wendy.

Now, while they were so happy in their house, through the wood came the terrible pirates. The captain of this frightful gang was named Captain James Hook, and a more horrible villain never froze the blood in a child's veins. All his crew feared him and cowered before him. His long black hair was enough to make you shiver; his yellow skin made you go white; his coal-black eyes struck daggers of fear into your heart; but, far worse than all these, more awful even than his cackling laugh and his way of rolling his "r's" so that they sounded like pistols, was his right hand. His right hand wasn't a hand at all, *it was an iron hook.* How he came to have that hook is part of the story.

Peter Pan had tripped the terrible pirate into the sea, and a crocodile, a tremendous *c-r-r-r-r-rocodile,* had



The Darling family at home, showing Michael on his father's back



Peter comes in at the window to look for his shadow

The little house that the lost boys built in the woods for Wendy

snapped off his hand and part of his wrist. Nor was this all. The crocodile enjoyed the captain's hand and wrist so much that it wanted more, and so it haunted the captain wherever he went, longing to eat another bit of him, and dreaming of the happy day when it would gobble him all up. The captain always knew when his ferocious enemy was near, because on one occasion it had swallowed an alarm clock, and the ticking of this clock could plainly be heard through its skin. But the captain feared, because he knew the clock would one day run down, and then the crocodile would be able to steal upon him unawares.

You can imagine how this pirate hated Peter, the cause of all his troubles, and how he longed to slay him.

One day, when some friendly Indians were guarding the boys, up came the pirates and made a great slaughter of the poor redskins. The boys did not hear the battle, for they were very interested in something that Wendy was telling them underground.

Wendy, you must know, had become the mother of these boys, and they all did exactly what she told them, and all adored her, because it was so delightful to have a mother after having lived so long without one. After she had seen mermaids and a bird that gave up its nest for Peter Pan to use as a boat, she settled down to be a real practical mother, giving the boys their medicine, teaching them how to behave nicely, and tucking them all up nice and comfy in their beds. Considering that she was only nine years of age, Wendy made a splendid mother.

Well, on this night, Wendy was telling them a story about her own father and mother—a beautiful story which showed how that mother and father must be weeping for their lost children. As she was finishing, John Napoleon and Michael Nicholas sprang up in their beds, and said:

"Wendy, we must go back!"

"Yes," answered Wendy, "we must go back."

You can imagine how dreadfully sad all the motherless boys were when they heard that Wendy was going home. They cried so much that at last she told them they might come back with her and her brothers, and live in their house, and have Mr. and Mrs. Darling for their father and mother. All the boys accepted this offer with delight except Peter Pan. Peter Pan said he did not want to grow up. He did not want to live in a real house and go to school. He wanted to live always in Never-Never-Land, with the fairies and birds and mermaids. In his heart he was terribly sad at losing Wendy, whom he loved very much indeed; but he refused to go away and grow up like an ordinary boy.

So they all said good-by to Peter Pan, and one by one went up the narrow tunnel which led from their underground home to the forest and the night. Wendy was the last to go, and before she went she poured out some medicine for Peter and made him promise her that he would take it when he woke up in the morning.

But instead of kind redskins keeping guard, the pirates were there. The boys were seized one by one as they stepped on ground; a rough hand was clasped over their mouths to prevent them from crying out, and they were carried away prisoners to the pirate ship with Wendy.

Peter Pan lay asleep in his bed. The rest of the boys were on board the pirate ship. Peter Pan was alone, and asleep.

Captain Hook was creeping to the hole above. Now was his chance to slay his enemy.

Noiselessly the pirate chief crept down the hole. He arrived at the door, and peeped over the top. Peter Pan was fast asleep. He tried to open the door, and failed. Again and again his hook fumbled at the latch, but failed. Peter Pan was safe. But no! The terrible captain espied the glass of medicine left by Wendy on a shelf; he reached towards it, and then, taking a bottle of poison from his pocket, poured the contents into the glass.

Peter Pan woke up. He remembered his promise to Wendy, and went to drink the poison. At that moment Tinker Bell rushed in crying:

"Don't drink! Don't drink!"

But her warning was useless.

"I have promised Wendy," answered Peter, and walked towards the glass with his hand outstretched.

In vain did Tinker Bell warn him; but, just as Peter was about to drink, the little Shining Light popped into the glass and drained all its deadly contents. Then it flickered and paled and drooped towards its bed, dying.

Peter knew there was only one way in which he could possibly save it.

"Do you believe in fairies? Oh, please say you believe in fairies!" he cried to all the world. And back from the world, which was so sorry for poor little Tinker Bell, came the answer:

"We believe in fairies."

So Tinker Bell revived and was saved, and she told Peter Pan how the pirates had carried off the lost boys, with Wendy and her brothers, to their ship, and of the danger in which they stood.

Peter immediately started out. He arrived at the ship just as the captain was going to flog his prisoners before making them walk the plank. Peter Pan had an alarm clock in his pocket; he took it out, and at the first sound of that *tick-tick* the captain gave a great cry of horror, thinking that the cr-r-r-rocodile was near.

During the panic, Peter stole on board ship and hid himself in the cabin where the cat-o'-nine-tails was hidden.

The clock ran down. The captain grew brave again.

"Go and get the cat-o'-nine-tails!" he ordered.

One of the ruffians went to obey. As he entered the cabin a terrible shriek resounded all over the ship. Another pirate was ordered to go and see what had happened. He, too, uttered a ghastly shriek, and did not come out.

The rest of the crew were now in a state of panic. They refused to enter the cabin; one threw himself into the sea.

Suddenly Peter Pan rushed out, sword in hand, and a terrible fight followed. Captain Hook was flung overboard, where the crocodile was waiting for him; and all the rest of the wicked pirates were killed.

Then Wendy and all the boys went home, and you can imagine how glad Mrs. Darling and Mr. Darling and Nana were to see their lost children. Mr. Darling, we must tell you, had been so repentant for his crossness that he had made Nana live indoors and dine at the table and occupy his own chair; while he himself slept in a kennel outside, and ate all his meals out of a dog's trough. Mrs. Darling had always kept the window open, hoping that the children would return; and used to play and sing "Home, Sweet Home," thinking that they might hear her and come back.

But Peter Pan, all alone in Never-Never-Land, longed for little Wendy; and Mrs. Darling allowed Wendy to go every now and then to visit Peter, and see that his house was nice and tidy. Peter Pan always refused to grow up, and Wendy never forgot the fairies.

LITTLE TINY THUMBELINE

ONCE upon a time there lived a young wife who longed to possess a little child, so she went to a fairy and said to her: "I wish very much to have a child, a little tiny child. Will you give me one, dear fairy?"

"With all my heart," replied the fairy. "Sow this barleycorn in a flowerpot, and then see what will happen."

"Thank you, thank you!" cried the woman, giving the fairy a silver coin. Then home she went, and planted the barleycorn, and immediately there shot up a large flower like a tulip, but with the petals tightly closed like a bud.

"What a lovely flower!" said she, and kissed it. The bud opened at once with a loud voice, and there, in the center of the flower, sat a little tiny girl about an inch high, scarcely bigger than her thumb. So she called her Thumbeline, and put her to bed in a walnut shell, with violet leaves for her mattress and a rose leaf for a quilt. During the day she told Thumbeline stories, and taught her to sing, as she played on the table beside her.

But one night a great, wet, ugly toad came and stole away the cradle with little Thumbeline asleep in it, and carried it off to her home in the muddy bank of the brook that flowed past the end of the garden.

"This is just the wife for my son," thought she. But when her ugly son saw her, all he could say was "Croak, croak, croak!"

"Don't make so much noise, or you'll wake her," said the old Mother Toad. "She may easily escape, for she is as light as a feather. We must take her out and place her on one of the large water-lily leaves in the middle of the brook, while I prepare our house for you both."

This they did, and when poor little Thumbeline awoke and found herself in the middle of the stream, she cried most bitterly.

As soon as old Mother Toad had decorated her home with bulrushes and yellow buttercups, she and her hideous son swam out to the leaf to fetch the cradle so as to place it in their new home before taking the little maid herself there.

Old Mother Toad bowed low in the water, and said: "Here is my son, who is going to be your husband. I will come and fetch you soon, and you will be very happy together."

Then they swam off with the cradle,

and poor, terrified Thumbeline wept bitterly. Now, some little fishes had overheard old Mother Toad, and when they saw the little maid so sad they gnawed away the stem of the leaf, and away it floated down the stream, so fast that the toad could not catch it. Thumbeline became happy again, for everything she passed was so lovely in the sunshine, and the birds on the branches sang to her as she floated by. A pretty little butterfly hovered round her, and at last settled for a moment on the leaf, for he loved her very much. She was pleased, too, and tied him to the leaf with her sash.

But presently a great ugly cockchafer came buzzing past. He caught sight of her, and snatching her off the leaf, flew up with her into a tree; but the poor butterfly could not free himself, and went floating along downstream. The cockchafer gave Thumbeline some honey to eat, and praised her beauty; but when the henchafers saw her, they said that she was just like a human being.

"How very, very ugly she is!" they all cried; and at last the cockchafer disowned her, and they all flew down with her and set her on a daisy. Then she wept because she was so ugly that the henchafers would have nothing to do with her.

All the summer Thumbeline lived alone in a wood, dining off the honey from the flowers, and drinking the dew that every morning spangled the leaves around her. But then came the cold, long winter; the flowers all died, the birds flew away, and the snow began to fall. Poor hungry Thumbeline wandered through the stubble of a cornfield hard by until she came to the hole of a field-mouse, who dwelt snugly down in the ground, having a room full of corn, and a neat kitchen and store-room.

The fairies came out from their flowers and brought Thumbeline presents

Thumbeline stood at the door and begged for food

"Poor little thing!" said the good-natured field-mouse. "Come into my warm room and dine with me." And she soon became so fond of the tiny maid that she said: "You may dwell with me all the winter, if you will only keep my room clean and neat, and tell me stories, for I love stories dearly." And Thumbeline agreed, and was very happy in her new home.

In a few days' time the field-mouse said: "We shall have my next-door neighbor, the mole, in to visit us to-morrow; he comes to see me once a week. He is richer than I am, has large rooms in his house, and wears a beautiful black velvet coat. It would be capital if you married him; but he is blind, and cannot see you, so you must tell him your prettiest stories."

When he came, Thumbeline sang to him, and he soon fell in love with her. He invited them to walk down a long, dark passage that he had just burrowed from their house to his, lighting them with a piece of tinder.

But when they had gone a short distance they found a swallow lying stretched on the floor; the poor bird had evidently died of cold. Thumbeline felt very sorry, as she loved all the birds, but the mole kicked it with his short legs, saying:

"Here's a fine end to all its whistling! What a miserable thing it must be to be born a bird! None of my children will be birds, thank goodness!"

But Thumbeline could not sleep that night, so she got up, and wove a carpet out of hay and then went and spread it round the bird; she also covered it with some warm, soft cotton.

"Farewell, dear bird," said she; "farewell, and thank you for your beautiful song in the summer, when all the trees were green and the sun shone so warmly upon us." And she pressed her head against his big body. To her great surprise she felt something beating within it. It was the bird's heart, and he was not really dead. She quickly laid the cotton more closely round him, and he gradually revived.

He remained underground all the winter, and Thumbeline was kind to him and brought him water and food; but she never said a word either to the mole or the field-mouse.

As soon as the spring came the swallow said farewell to Thumbeline, who would not go with him, because she knew it would vex the old field-mouse if she left her.

Thumbeline was now sad indeed, for she was not allowed to go into the warm sunshine.

"This summer you must work and make your wedding clothes," said the field-mouse, for the blind, dull mole had decided to marry Thumbeline.

So the tiny maid was obliged to work hard at the distaff, and the field mouse hired four spiders to spin and weave.

Every evening the mole came and talked about how the summer was coming to an end, and he abused the sun and pretty flowers so much that Thumbeline disliked him more and more, and said she would not marry him.

"Fiddlestick!" cried the field-mouse. "Don't be obstinate, child, or I will bite you with my white teeth."

At last the day fixed had arrived, and Thumbeline went to bid a last farewell to the beautiful sun before going to dwell with the mole deep down in the earth.

"Farewell, thou glorious sun!" she cried, as she walked a little way.

"Tweet, tweet!" And she heard a fluttering of wings, and there was the little swallow. She told him her sad fate and how she longed to be free.

"The cold winter will soon be here," said the swallow; "I shall fly far away to the warm countries. Come with me, sweet little Thumbeline, who didst save my life when I lay frozen in the dark earth."

"Yes, I will go with thee," said she; and she seated herself on the bird's back, and then the swallow soared high into the air and flew away over forest, lake, and mountain, until they reached the warm countries. There the sky seemed twice as high and twice as blue, and there grew the loveliest green and purple grapes, and citrons, and melons.

Near a calm, blue lake stood a half-ruined palace of white marble, and here the swallow had built his nest.

"This is my house," said the swallow, "but I will take you to one of the splendid flowers growing beneath us, and you shall dwell in one of them."

But what was her surprise when she saw sitting on the flower a little manikin wearing a gold crown on his head and the brightest, most delicate wings on his shoulders, scarcely any bigger than herself. He was the spirit of the flower, and in every flower there dwelt one such fairy, and he was their king.

When he saw Thumbeline he was delighted, for he had never seen so lovely a maiden. So he put his gold crown on her head and asked her to be his queen. And Thumbeline said "Yes," and then all the fairies came out from their flowers and brought her presents, and the best of all was a pair of transparent wings, which enabled her to fly from flower to flower.

"You shall no longer be called Thumbeline," said the king to her, "for it is not a pretty name, and you are so lovely. We will call you Maia."

And she dwelt with him ever after.

THE PYGMIES

THERE is an old saying that "truth is stranger than fiction." This seems to be just as true today when we read the stories of recent travelers and explorers about the strange peoples and races they find in the wilds of distant lands. One of the most wonderful recent discoveries is that of a new race of pygmies that dwell on the flanks of the great Snow Mountains in Dutch New Guinea, Africa.

Ancient writers were fond of recounting the adventures of these little people, and the folklore of Africa and Asia and Europe bases many of its strangest stories upon pygmy life. Our nursery tales of gnomes and fairies, goblins, pinkies and brownies have undoubtedly come down, generation after generation, by word of mouth, from the dim, primeval days when pygmies wandered dry shod across the land-bridge that connected India with Africa, and when the island of Sicily was part of the highway from northern Africa into Southern Europe. Although no pygmy in the wilds has ever seen pencil or paper, yet the race is immortalized in the company of Trojan and Greek, and until modern times has been regarded as equally mythical.

Homer, who lived in the ninth century B. C., began the story, comparing the arming Trojans, rushing to war, with cranes migrating to the pygmies' land:

"So when inclement winters vex the plain
With piercing frosts, or thick-descending rain,
To warmer seas the cranes embodied fly,
With noise, and order, through the midway sky,
To pygmy nations wounds and death they bring . . ."

BATTLING WITH THE STORKS

Aristotle, another Greek, knew full well of the existence of pygmies; Herodotus describes them as battling with the storks which came to raid their crops. These and other ancient writers got the main fact correct as to the existence of the little people; but, as in other dealings with natural history, they mingled the marvelous with the matter-of-fact. Their tales of pygmies with pygmy horses and other tiny, domesticated animals, of the tiny people having to cut down their crops with axes, of their requiring a ladder to mount into the goblet of Hercules, were, of course, as fabulous as the legend of their fashioning the spear of Odin and the world-shaking hammer of Thor. And because of this leaven of romance the whole story of pygmies was discredited until certain African travelers burst into the twilight gloom of the forests and first discovered a kingdom of real midgets.

There are two groups of pygmies now known—Negrillos and Negritos—consisting of many tribes. Some are found in the Andaman Islands, in the Bay of Bengal; half a dozen distinct tribes are in the Congo; there are the tiny Bushmen of South Africa, the Aetas of the Philippine Islands, the Samange of Malacca, the pygmy tribes in Formosa, and now, also, these little people in Dutch New Guinea.

Herodotus, the ancient Greek writer, was then not wholly mistaken in describing his pygmies as defending their crops against great birds.

The latest discoveries in Dutch New Guinea are on the side of the ancients. The Tapiros, as the newly known midgets are called, do cultivate crops. They cultivate sweet potatoes, tobacco, and sugar-cane. African pygmies of today have no crops, but they wage war upon the giant cranes which haunt the head waters of the Nile.

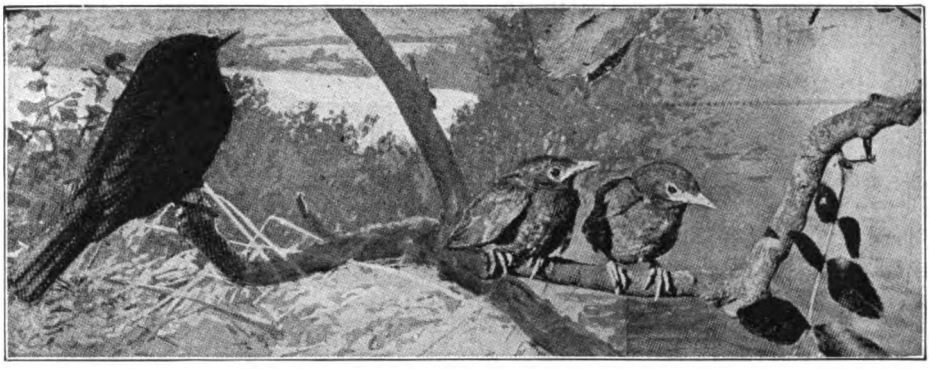
They knew the use of fire and, in a primitive way, iron-smelting and working. Their spear-heads are of iron, smelted and worked by themselves, and the tips are poisoned with a virus of terrible potency. They live in tiny huts in the forest—huts only 4 feet in height, bare of any suggestion of furniture, and entered by a low opening through which the tenant crawls on all fours. Spears are their only assets. These constitute the purchase price of a bride, and upon the product of the weapon they live. They attack and kill the mighty elephant; they hunt the okapi. It is a strange fact that the discovery of the Congo pygmies gave this extraordinary animal to the knowledge of the world. No white man had ever seen an okapi ten years ago, and only rumors of its existence had been heard.

At home the pygmies are feared and avoided by other natives. They inhabit the reeking, steaming forest, impenetrable to all save themselves, and pass their lives in a perpetual twilight, amid mighty trees laced and bound together with vast creepers, in and out of which little men run like rabbits.

The same habits and method of living distinguish the majority of pygmy tribes. For the most part all have like features: the dark skin, the ape-like mouth; the broad, flattened nose; the woolly, "pepper-corn" hair.

Like the tiny Shetland ponies and the diminutive Shetland sheep dogs, the pygmies make up in intelligence what they lack in inches.

But the pygmies most recently discovered—those of Dutch New Guinea—appear to be in advance of their fellows. They are husbandmen, growing their own crops. They make bows and arrows, and use them with astonishing skill, employing them against birds, rats, mice, and other small animals.



THE ARTFUL MOLE AND THE INNOCENT BLACKBIRD

"Tell us about the most wonderful escape you ever had from an enemy, will you, daddy?" said an excitement-loving little Blackbird, sitting alongside one of his brothers on a twig overhanging a cattle pond.

"Oh, let me see, let me see," mused the sable old bird with the orange bill. "I think the most curious adventure I ever had, and certainly the narrowest escape, happened to me when I was a young fellow, just learning to sing.

"Blackbirds are all early risers, and I used to leave my cozy roosting perch under a tuft of ivy at the first peep of day regularly every morning, in order to listen to my father, who was a capital singer, and such a cunning old bird, too!

"One day he said to me, 'Jack, do you know an easy way to catch worms?'

" 'No, father,' I answered.

" 'Well, I'll tell you, then, lad. If ever you see a mole at work throwing up a hillock of earth, just hop quietly along to the place, and ninety-nine fat caterpillars to a lean daddy longlegs, you'll observe a terrified worm or two hurrying to the surface of the ground in order to escape from their enemy below. Once they have left their holes you can pick them up and swallow them as easily as ever you please, for it's what men call a case of "out of the frying pan into the fire" so far as the worms are concerned.'

" 'Thank you very much indeed. That is a pretty wrinkle, and no mistake, dad,' said I with glee.

" 'Yes, Jack,' replied my father, 'but it's just like all pretty things—it needs to be approached with care, as the puppy dog said when he tried to play with the wasp. You must be very careful the mole does not catch hold of you, for he is an awful cannibal, and the monster that will eat his own grandmother would not hesitate to breakfast off you.'

"Being dragged underground alive and devoured in a mole's dark tunnel struck me at the time as being rather an unpleasant way of ending one's career; but warnings have a trick of slipping from the minds of over-confident young people, and I had forgotten the dangerous side of my father's information in less than a week.

"I was standing on the topmost branch of a dead tree early one morning, listening intently to my worthy parent's top notes, when I observed a tiny clod of earth roll off the top of a newly made mole hill. Now's my chance, thought I, never dreaming of the great surprise in store for me.

Keeping my eye steadily fixed on the spot, I saw the mole give another heave, and out came a great red worm, helter-skelter. I was on him like a shot, and thought I had never in all my life tasted such a delicious morsel.

"I waited about for some time, feeling sure that other worms would come to the surface; but in vain, the mole had ceased to work.

"By-and-by, a monster just showed his great pink head on the crown of the newly-made hillock, and I grew so excited I could hardly stand still.

"I waited and waited, and as the mole did not burrow any more the worm also waited and waited. I naturally supposed that as there was no enemy at work beneath him he did not see the fun of coming out to make a meal for me, so I decided to pounce upon him and drag as much of his body out as I could.

"I made a wild dash at him, and never got such a fright in all my life."

"Whatever happened, daddy?" asked both the young Blackbirds excitedly.

"Well, what I supposed to be the head of a worm proved to be the nose of the artful old mole. Whether he had stuck it out in order to get a breath of fresh air, or as a deliberate bait for me, will never be known; but directly I seized it he seized me, and it is a wonder I'm alive to tell the tale.

"The brute instantly tried to drag me underground, but being a strong young bird and my bill hard and slippery he lost his hold, and I made my wings go faster than they ever flapped before or since.

"It was a full week before I dared look at a worm again.

"Take my advice, children, and examine early worms well, especially when they thrust their heads out of mole hills. Man-made proverbs need applying with caution, and I should tie on behind 'It is the early bird that catches the worm,' but 'All is not gold that glitters.' "

THE ARCHER FISH—A FINNY SPORTSMAN

MANY tall stories have been discredited since scientists began sternly to demand proof of alleged facts, but nevertheless it has been recently established that there are fish that share with man the sporting instinct. Of these finny sportsmen the Archer is king.

"We have," said Sir Charles Bell, "a curious instance of the precision of the eye and of the adaptation of muscular action, in the beaked chætodon, a fish which inhabits the Indian rivers and lives on the smaller aquatic flies. When it observes a fly alighted on a twig, or flying over it—for it can shoot them on the wing—it darts a drop of water with so steady an aim as to bring the fly down into the water, when it falls an easy prey. It will hit a fly at the distance of from three to six feet. Another fish, of the same order, the Zeus, has the power of forming its mouth into a tube and squirting at flies, so as to encumber their wings and bring them to the surface of the water. In these instances a difficulty will readily occur to the reader. How does the fish judge of position, since the rays of light are refracted at the surface of the water? Does instinct enable it to do this, or is it by experience?"

Nearly a century ago travelers reported having seen specimens of the Jaculator fish in Java. They were exhibited by a native chief, who kept them in a pond, in the middle of which was placed a short branch. For the amusement of his visitors the chief

instructed attendants to place living beetles on it.

EXPERT GUNNERS

"When the slaves had placed the beetles, the fish came out of their holes and swam around the pond," says one account. "One of them came to the surface of the water, resting there, and, after steadily fixing its eyes for some time on a beetle, it discharged from its mouth a small quantity of water with such force and precision of aim as to strike it off the twig into the water, and in an instant swallowed it. After this another fish came and performed a similar feat, and so the sport continued until they had secured all the beetles. If a fish failed in bringing down its prey at the first shot, it swam around the pond till it came opposite the same object, and fired again. In one instance a fish returned three times to the attack before it secured its prey, but in general the fish seemed very expert gunners, bringing down the beetle at the first shot."

When the Jaculator fish intends to catch a fly or any other insect which it sees at a distance, it approaches very slowly and cautiously, and goes as much as possible perpendicularly under the object; then, the body being put in an oblique position, and the mouth and eyes being near the surface of the water, the Jaculator stays a moment quite immovable, having its eyes directly fixed on the insect, and then begins to shoot, without ever showing its mouth above the surface of the water, out of which the single drop, shot at the object, seems to rise. With the closest attention, one can never see any part of the mouth out of the water, though the Jaculator fish shoots a great many drops one after another without leaving its place and fixed situation.

They frequently swim backwards as well as forwards, says Zolotnitsky, a Russian savant. This habit of swimming backwards is very curious and quite customary; indeed, they often swim in this manner for several minutes at a time. They reconnoiter a possible prey, and back from it until they secure a good position for observation and attack.

The action of the eyes deserves special notice. They can be moved in almost every direction—to the left, to the right, upwards, and backwards —backwards so that the fish can see everything that goes on behind. Their vision is also very penetrating; they can see small objects at a great distance, and drench them with astonishing correctness of aim. But the eyes cannot be turned downwards, and, consequently, when the fish would see what is below, it plunges forward, head foremost. It rarely sees what is at the bottom, and although worms may be there in abundance, it finds them only when hunger impels it to search for them there. And it is not alone the movement of the eyes which engages attention; instead of the expressionless stare which is characteristic of fishes generally, the Archer's eyes sparkle with intelligence. Especially when the fish becomes sick or dying is the expression manifested; then it looks at you as if it would implore your attention and would like to speak. Apparently there are few limits to the ingenuity of the Archer fish. This finny tribe certainly does not seem to be less greedy than its fellows. It appears that the less expert gunners, finding that their clumsy efforts merely resulted in driving insects away from the aquarium, desisted in favor of the adepts of the family. When the latter exercised their skill, the other fish waited in readiness to snap up the spoil before the successful sportsman could secure it.

LITTLE PLAYS AT HOME

HINTS: 1. Stage Properties are those articles which are used in a play either for scenery or for dress. One child should be appointed to look after these properties. He must see that they are in their proper places before the curtain rises and at hand as the scene goes on.

2. Each child is responsible for his own personal properties, that is to say, the articles of dress, swords, armor, etc., belonging to his part.

3. In setting or arranging the scenery, the Right is on the right hand and the Left on the left hand as you stand facing the stage, with your back to the audience.

4. The Prompter should stand, out of sight of the audience, at the side of the stage, book in hand, ready to give the missing word or sentence, should any one forget his part.

SCENE FROM ROBIN HOOD

CHARACTERS: KING RICHARD CŒUR DE LION; Three Nobles, attendants on him; ROBIN HOOD; LITTLE JOHN; MUCH; ALLAN-A-DALE; FRIAR TUCK; Robin Hood's Merry Men; MAID MARIAN; LADY CHRISTABEL.

STAGE PROPERTIES: Green cloth for floor, bank, bushes, mugs, platters, jug for wine, dishes, dinner things, silver and crystal bowl. For the bank, a biggish box banked up with cushions. Cover it with cloth and ivy. Bowl in bright new tin basin, and crystal fruit dish. For dinner dishes, have as many covered dishes as possible, plates of fruit, bread, etc. Sham fowls, meat, etc., can be bought, but these are not necessary with covered dishes. A big soup tureen looks well. This scene can be acted out of doors.

SCENE: An open space in Sherwood Forest. To the *Right* and *Left*, trees or greenery; at the back a bank. When the curtain rises KING RICHARD is discovered standing in center; near him the three Nobles. They are all dressed in monks' cloaks, with hoods well drawn over their faces.

THE KING [*looking round him*]: Well! I hope we shall see the fellow this time.

FIRST NOBLE: There is not much fear of that: Robin Hood finds out monks as quickly as bees do honey. We shall not have long to wait, your Majesty.

THE KING [*softly, putting finger on lip*]: Hush! He may be listening now, and if he guesses who I am our game is spoilt. Remember I am only an abbot for today. [*louder*] The fellow is well off here: sunshine and green trees, flowers and the song of the birds for company—who could want more?

SECOND NOBLE [*speaking quickly*]: I saw something moving down there . . . through the trees . . . take care, my Lord!

THE KING [*still loudly*]: For my part, I have no fear of the man He would not dare rob *me*.

ROBIN HOOD [*stepping from behind a tree, all in green, with bow and arrow,*

and horn]: You speak too soon, my lord abbot—for an abbot I take you to be by your dress and manner. Robin Hood dare rob whom he will, when he has need of money, so you had better come with me peacefully. I have a hundred men within call, and I am not over fond of monks.

THE KING: If we are monks, we are also messengers from the King. If you are the famous Robin Hood . . .

ROBIN HOOD: I am Robin Hood.

THE KING: Then his Majesty sent us to say that he would see you. As a sign he sends you this ring [*showing ring on his hand*].

ROBIN HOOD [*after looking at it, taking off his hat*]: It is truly the King's ring. God bless him: God bless all those that love him: cursed be all those who hate him and rebel against him.

THE KING: Then you curse yourself, for you are a traitor and an outlaw.

ROBIN HOOD [*fiercely*]: I am an outlaw may be, through no fault of mine, but I am no traitor, and if you were not the messenger of the King you would pay dearly for that lie. I have never yet hurt any true and honest man: I have robbed only from the tyrant rich, never from the poor: I fight against monks and abbots, and take their money from them when I can, because they steal from the poor. They ought to live good lives and show others a good example, but they do not. They live wickedly, and should be punished. If they had ruled England well when King Richard was away, we should not have to live in the woods as we do now. [*Kindly.*] But do not fear, you are the King's messengers, and therefore welcome to all that we have. Stay here, and sup with us; we will make you comfortable as we know how.

THIRD NOBLE: They wait for us at Nottingham, my lord.

THE KING: Let them wait: the King wishes to know as much as possible about this man. If we do not fare well, it will matter not for once.

ROBIN HOOD: You shall eat of our best, Sir Abbot, though if you came not from the King I doubt if you would be so well treated.

[*Blows his horn. Enter quickly* LITTLE JOHN, MUCH, ALLAN-A-DALE, *and others: they are all dressed in green.*]

LITTLE JOHN: What news, master?

ROBIN HOOD: None that will fill our pockets, my little John. These good monks are messengers from the King, and therefore safe from us. Much!

MUCH: Yes, master!

ROBIN HOOD: . . . Tell the cook that we shall dine here, and that we must have as fine a feast as if the King himself were among us.

MUCH: Yes, master! [*Goes out by Left quickly.*]

ROBIN HOOD: Allan - a - dale, go bring me here Maid Marian, and your sweet Christabel; tell them we have need of their help to entertain our noble company.

ALLAN-A-DALE: I go right gladly, master. [*Exit by Left.*]

ROBIN HOOD [*to the others*]: Now, men, help bring the things and do your parts with a right good will. Let us show these gentlemen what we poor foresters can do.

ALL: Ay, that we will, master!

[*Exit all foresters, save* LITTLE JOHN. *They all drop on one knee before* ROBIN *as they pass out.*]

THE KING: Upon my word, Sir Outlaw, you are master of a gallant company. It is a pity that you should live as you do—shooting down the King's deer, robbing his faithful bishops and knights.

ROBIN HOOD: I cannot starve my men, Sir Abbot, and were Richard himself here I think he would scarcely grudge these fine men their food.

THE KING: Perchance not, but it is against the law.

ROBIN HOOD: I know that well, Sir Abbot, but what else can we do? Our homes have been burned down by the Norman nobles, our lands have been stolen, our money taken, and they would have made us their slaves. Rather than that, we have chosen to live here in the merry greenwood. We are Englishmen, Sir Monk, and we would be free.

THE KING: Well spoken! Well defended, Robin!

[*Enter by Left* ALLAN-A-DALE, *with* MAID MARIAN, LADY CHRISTABEL, *and* FRIAR TUCK.]

MAID MARIAN [*curtsying*]: Welcome to Sherwood Forest, Sir Abbot!

THE KING: Who is this fair lady?

FRIAR TUCK [*pushing forward*]: Have you never heard of Maid Marian, Robin Hood's sweet bride, and Queen of our merry greenwood? She comes of noble blood, but rather than be parted from her Robin she fled to the forest all in knightly array. There she again met our master, and the two young things fell to fighting together, neither knowing the other; presently Robin spoke and the lady discovered herself, and the end of it all was that I married them myself. Ah, it was a merry wedding!

THE KING: Who is this jolly monk?

FRIAR TUCK: Friar Tuck, at your service, my lord abbot, and a very busy man. Look at these two [*pointing to* ALLAN-A-DALE *and the* LADY CHRISTABEL]. I married them under the old bishop's nose: I cried them seven times in the church lest there should be some mistake. They are a couple to be proud of. They . . .

ROBIN HOOD: Friar Tuck, Friar Tuck, your tongue clacks too loudly.

FRIAR TUCK: Not so, master, not so; you would be badly off without its clacking, I'll warrant. Who would marry you? Who would bless you? Who would say grace at meat in the Latin tongue? Who would . . .

[LITTLE JOHN *takes him by the arm and leads him away.*]

ROBIN HOOD [*laughing*]: He is a merry soul!

[*Enter a Page (or Pages) with silver or crystal bowl and towel. He kneels before the* KING, *holding the bowl while he washes his hands, then goes to the Nobles. Men in green come hurrying in with mugs, platters, dishes, food, etc., which they set on the grass.* LITTLE JOHN *orders them here and there: the* KING *and Nobles talk to* MAID MARIAN *and* CHRISTABEL. *Presently* ROBIN HOOD *blows his horn: all the men stand round.*]

ROBIN HOOD: Fill up the mugs, men, to the very brim: before we eat we will drink the King's health.

[*They fill up mugs, giving them also to the* KING *and Nobles.*]

ALL *drinking* [*led by* ROBIN HOOD]: God save the King!

THE KING: If I could get you pardon from the King, Robin, would you be willing to leave this wild life in the woods and serve him forever? He has need of loyal and true men like you.

ROBIN HOOD: With all my heart!

THE KING [*to the men*]: Men, would you be willing to serve the King of England, Richard Cœur de Lion?

ALL [*flinging their caps into the air*]: With all our hearts! . . . God save the King!

ROBIN HOOD: You see, Sir Abbot, we are all loyal people here.

THE KING [*huskily*]: So I see!

ROBIN HOOD: If you would but ask the King to forgive me, I think I

could once more respect monks. A bishop was the first cause of all our misfortunes, and because of that I have hated them all, but from this day I shall respect them.

THE KING [*flinging back the monk's hood*]: There is no need to ask the King for pardon. I am the King, your sovereign, and I forgive you gladly, Robin.

ROBIN HOOD [*falling on his knees*]: O Sire!

THE KING: Stand up, stand up, my friend: I doubt if in all England, I have more faithful followers than you and your men.

LITTLE JOHN: The King! God save us! . . . The King! !

MUCH *and Others:* The King! The King! [*They all kneel.*]

THE KING: Rise, all! I am King Richard of England: are you ready to follow me as your master, and be my men?

ALL: We are, we are!

THE KING [*gaily*]: Then let us sup, and after we will to Nottingham, and surprise them.

ALL: Long live the King! Three cheers for Cœur de Lion! And three for Robin Hood!

[*The* KING *gives his hand to* MAID MARIAN, ROBIN HOOD *to* CHRISTABEL. *As they all seat themselves round the feast the* CURTAIN *falls.*]

SCENE FROM UNCLE TOM'S CABIN

CHARACTERS: MISS OPHELIA, EVA, TOPSY.
STAGE PROPERTIES: Bed or sofa arranged as bed, and any other bedroom furniture. Ribbon, gloves, dressing table, etc.
NOTE.—In this scene there is no need to keep strictly to stage directions. Set it as seems most convenient.
SCENE: MISS OPHELIA'S bedroom: Door to the *Left;* at the back in center a bed, or couch arranged as bed, standing out from the wall; to the *Right* side of the bed, a dressing-table: on it, besides the usual looking-glass, etc., a bright red ribbon and a pair of white gloves. Chair to *Right* near front of stage. Bookcase, pictures, and other furniture, according to convenience. When the curtain rises, MISS OPHELIA is discovered sitting on chair to *Right;* opposite to her stands TOPSY, hands folded, eyes fixed on the ground.

MISS OPHELIA: Now, Topsy, you are clean and tidy at last, I hope?

TOPSY: Laws, yes, Miss Feely! There's not a speck o' dirt left on me.

MISS OPHELIA: That is better: I hope you will always keep clean and tidy in the future. There is nothing I dislike so much as dirt.

TOPSY [*rolling her eyes and making a face*]: Yes, missis.

MISS OPHELIA: Now I have a few questions to ask you before we set to work. How old are you, Topsy?

TOPSY [*grinning*]: Dunno, missis.

MISS OPHELIA: Don't know how old you are! Did nobody ever tell you? Who was your mother then, child?

TOPSY [*with another grin*]: Never had none.

MISS OPHELIA: Never had any mother! What do you mean? Where were you born?

TOPSY: Never was born.

MISS OPHELIA [*sternly*]: You mustn't answer me like that, child. I am not playing with you. Tell me where you were born and who were your father and mother.

TOPSY [*emphatically*]: Never was born, never had no father, nor mother, nor nothin'!

MISS OPHELIA: Topsy, how can you say such things! How long have you lived with your master and mistress?

TOPSY: Dunno, missis.

MISS OPHELIA: Is it a year, or more, or less? Try to answer properly this time.

TOPSY: Dunno, missis.

MISS OPHELIA: Worse and worse!

Do you know anything at all, I wonder! Have you ever heard of God, Topsy? [TOPSY *shakes her head.*] Do you know who made you?

TOPSY [*laughing*]: Nobody as I knows on: 'spect I grow'd. Don't think nobody ever made me.

MISS OPHELIA [*shocked*]: Terrible! whatever shall I do with a child like this! Do you know how to sew, Topsy?

TOPSY: No, missis.

MISS OPHELIA: What can you do? What did you do for your master and mistress?

TOPSY: Fetch water, wash dishes, and clean knives and wait on folks.

MISS OPHELIA [*going to left side of bed*]: Well now, Topsy, I'm going to show you just how my bed is to be made. I am very particular about my bed. You must learn exactly how to do it. Come to the other side and watch me well.

TOPSY [*going to right side*]: Yes, ma'am.

MISS OPHELIA: Now, Topsy, look here. This is the hem of the sheet, This is the right side of the sheet. This the wrong. Will you remember?

TOPSY [*with a big sigh*]: Yes, ma'am.

MISS OPHELIA: Well now, the undersheet you must bring over—like this—and tuck it right down under the mattress, nice and smooth—like this. Do you see?

TOPSY [*with a bigger sigh*]: Yes, ma'am.

MISS OPHELIA: But the upper sheet must be brought down and tucked under, firm and smooth at the foot—like this—the narrow hem at the foot.

TOPSY [*snatching the gloves and the ribbon off the dressing-table, as* MISS OPHELIA *bends over the bed*]: Yes, ma'am. [*Slips them into her sleeve.*]

MISS OPHELIA [*pulling off the clothes again*]: Now, Topsy, let me see if you can do it. [TOPSY *quickly and neatly makes the bed again.*]

MISS OPHELIA [*watching her*]: Very good . . . very good indeed, Topsy! We shall make something of you yet.

TOPSY [*tucking in the sheet*]: Yes, missis. [*As she does so the ribbon falls from her sleeve.*]

MISS OPHELIA [*picking it up*]: What is this? You naughty wicked child, you have been stealing!

TOPSY [*very surprised*]: Why! That's Miss Feely's ribbon, an't it? How could it a' got into my sleeve?

MISS OPHELIA: Topsy, you naughty girl, don't tell me a lie. You stole that ribbon.

TOPSY: Missis, I declare I didn't. Never seed it till dis blessed minnit.

MISS OPHELIA: Topsy, don't you know it is wicked to tell lies?

TOPSY: I never tell no lies, Miss Feely. It's jist the truth I've been tellin' now. It an't nothin' else.

MISS OPHELIA: Topsy, I shall have to whip you, if you tell lies so.

TOPSY [*beginning to cry*]: Laws, missis, if you whips all day couldn't say no other way. I never seed that ribbon. It must a' caught in my sleeve. Miss Feely must a' left it on the bed, and it got caught in the clothes, and so got in my sleeve.

MISS OPHELIA [*angrily shaking her*]: Topsy, how dare you! Don't you tell me that again. [*The gloves fall to the floor.*]

MISS OPHELIA [*holding them up*]: There! Will you tell me you didn't steal the ribbon?

TOPSY [*still crying loudly*]: O missis, missis, I'se so sorry! I won't never do it again, I won't.

MISS OPHELIA: Stop crying then, and tell me if you have taken anything else since you have been in the house. If you tell me truthfully, I won't whip you.

TOPSY: Laws, missis, I took Miss Eva's red thing she wears on her neck.

MISS OPHELIA: You did, you

naughty child! Go and bring it me this minute.

TOPSY: Laws, missis, I can't—they's burnt up.

MISS OPHELIA: Burnt up? What a story! Go and get them or I shall whip you.

TOPSY [*groaning and crying*]: I can't, I can't, Miss Feely! They's burnt up, they is.

MISS OPHELIA: What did you burn them up for?

TOPSY [*rocking to and fro*]: 'Cause I'se wicked, I is. I'se mighty wicked. I can't help it.

[*Enter* EVA *wearing red necklace.*]

MISS OPHELIA: Why, Eva, where did you get your red necklace?

EVA: Get it? Why, I have had it on all day, and what is funny, aunty, I had it on all night. I forgot to take it off when I went to bed.

MISS OPHELIA [*lifting her hands in despair*]: Whatever shall I do with her! What in the world made you tell me that you took the necklace, Topsy?

TOPSY [*wiping her eyes*]: Missis said I must 'fess. I couldn't think of nothin' else to 'fess.

MISS OPHELIA: But of course I didn't want you to confess things you didn't do; that is telling a lie just as much as the other.

TOPSY [*very surprised*]: Laws now, is it?

MISS OPHELIA: Topsy, what makes you behave so badly?

TOPSY [*grinning*]: Dunno, missis; 'spects it's my wicked heart.

MISS OPHELIA: What shall I do with you? I'm sure I don't know; this is terrible.

TOPSY: Laws, missis, you must whip me. I an't used to workin' unless I gets whipped, but I dunno that it helps much neither.

MISS OPHELIA [*going to door*]: I never saw such a child! Topsy, if you do not try to be more honest, and better in every way, I shall have to speak to your master. [*Exit.*]

EVA: What makes you so naughty, Topsy? Why don't you try to be good? [*Taking her hand.*] Don't you love anybody, Topsy?

TOPSY [*blinking her eyes*]: Dunno nothin' 'bout love. I love candy, that's all.

EVA: But you love your father and mother?

TOPSY: Never had none: I telled ye that before, Miss Eva.

EVA [*sadly*]: Oh, I forgot: but hadn't you any brother or sister, . .

TOPSY [*interrupting*]: No, none on 'em. Never had nothin' nor nobody.

EVA: But, Topsy, if you would only try to be good, you might . . .

TOPSY [*interrupting*]: Couldn't never be nothin' but a nigger, if I was ever so good. If I could come white, I'd try then.

EVA: But people can love you, if you are black, Topsy. Miss Ophelia would love you if you were good.

TOPSY [*laughing*]: Would she though?

EVA: Don't you think so?

TOPSY: She can't bear me, 'cause I'm a nigger. She'd as soon have a toad touch her. There can't nobody love niggers, and niggers can't do nothin'. I don't care. [*Whistles or hums, and tosses her head.*]

EVA [*laying her hand on* TOPSY'S *shoulder*]: O Topsy, I will love you: I love you now, because you haven't any mother or father or friends. And it makes me sorry to have you so naughty. I wish you would try to be good, Topsy. Won't you?

[TOPSY *suddenly sits down on the floor and hides her face in her apron.*]

EVA [*stroking her head*]: Poor Topsy!

TOPSY: O Miss Eva, dear Miss Eva, I will try . . . indeed I will. I never did care nothin' about it before.

CURTAIN.

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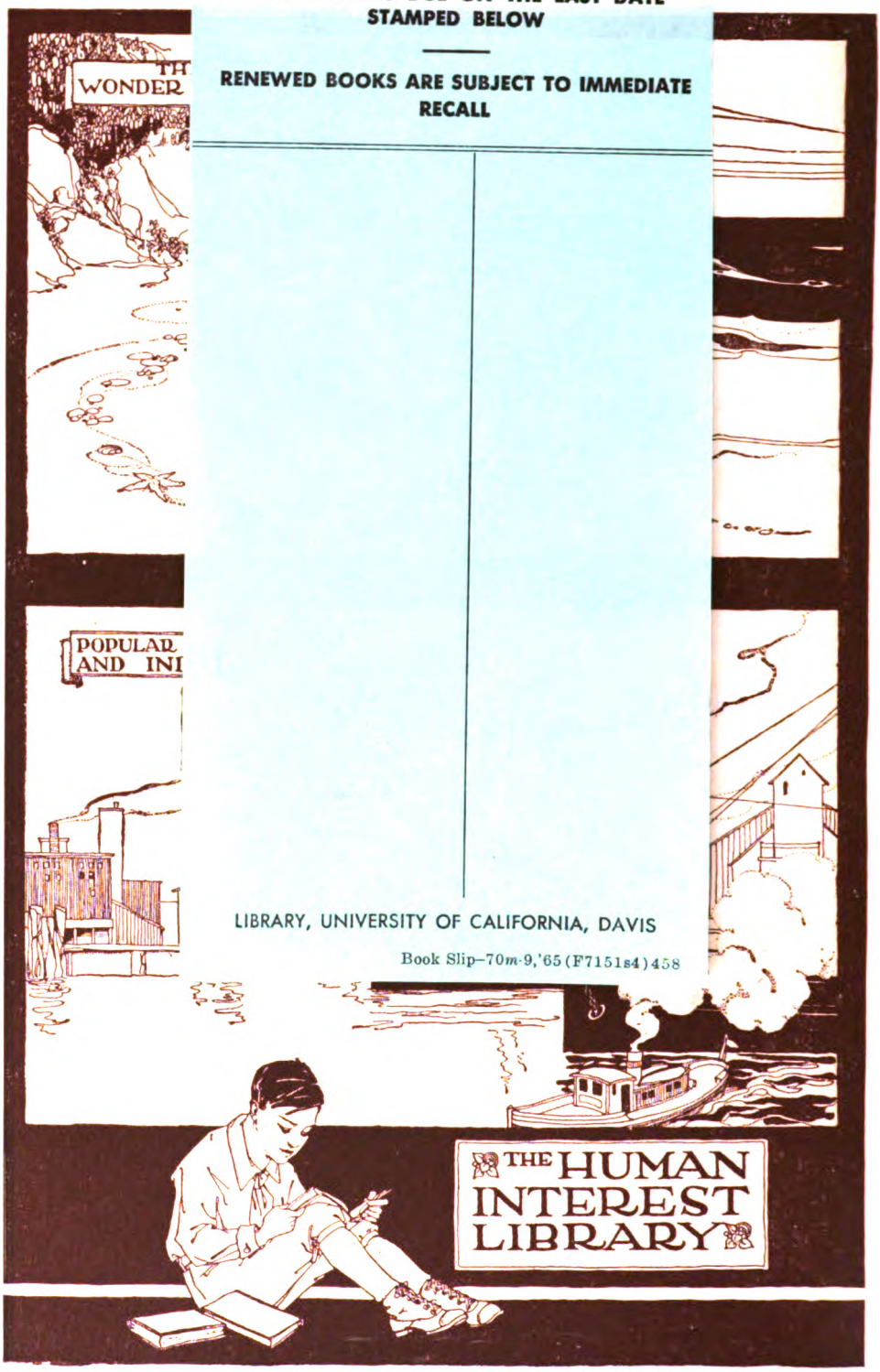

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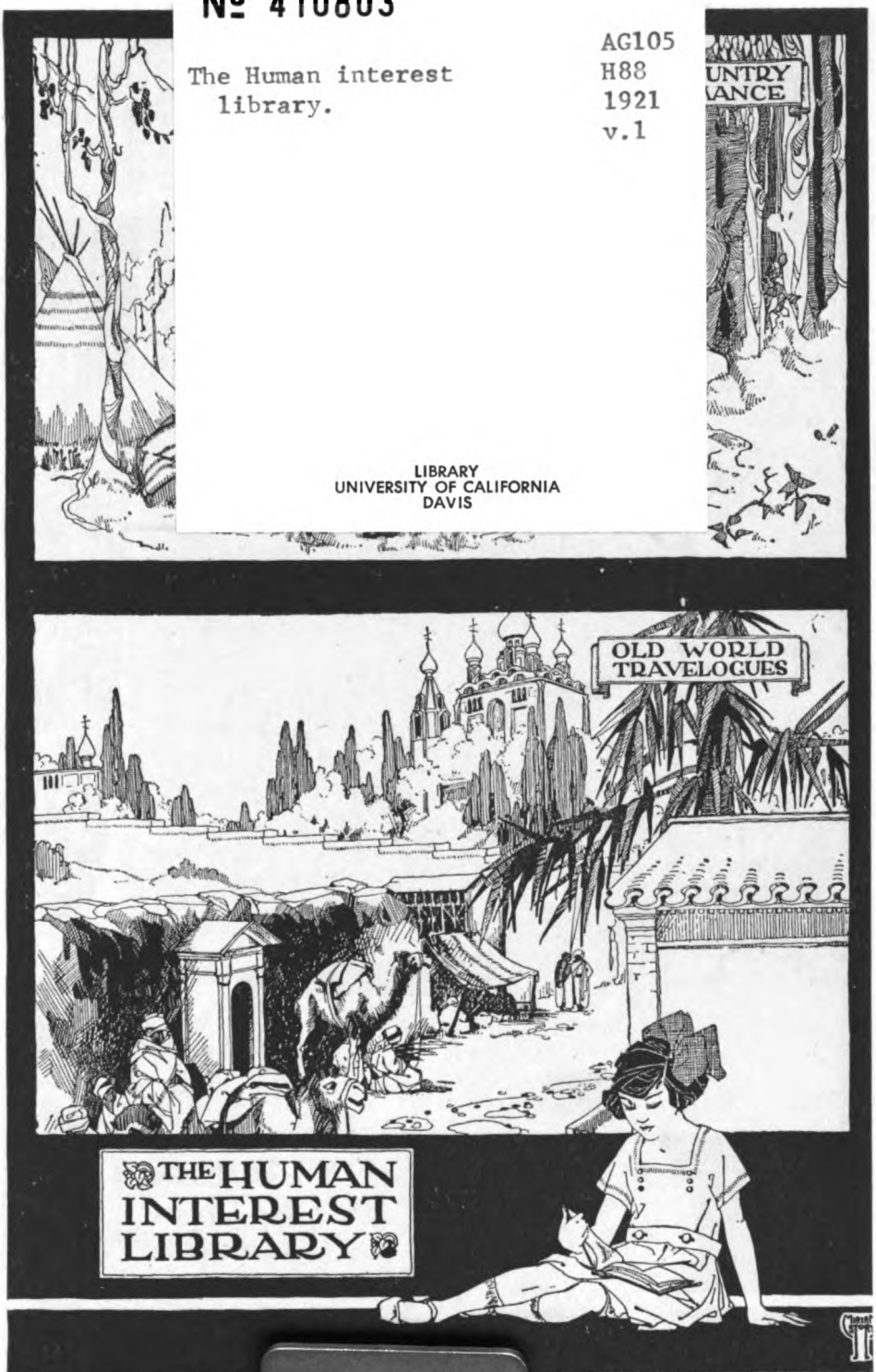
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